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From Knowledge to Wisdom

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Contents

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Evaluation of Biophysical Parameters and Temporary Space Change in an Arid City of Northwestern México

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Abstract: Through an analysis of Landsat multispectral images of visible, thermal and near-infrared bands, the spatiotemporal change of biophysical parameters: NDVI (normalized difference vegetation index), blackbody temperature and albedo, were estimated for Mexicali city, using principal component analysis and time series. The satellite images correspond to the dates: April 6, 1993; May 3, 2000; May 12, 2003; May 17, 2008 and May 26, 2011; the results reveal a change in relation to urban growth. In 1993, the vegetation was 20% and in 2011 it decreased to 3.8%. The blackbody temperature increased from 34.0 °C to 41.0 °C and albedo decreased by 0.37 compared to 1993. The most deteriorated area appears in surroundings of the city because of the change in the vegetation cover by the urban elements.

Key words: NDVI, blackbody temperature, albedo, Mexicali city.

1. Introduction

The different land use is determinative for location of human and social systems and influences the possible fragmentation of habitats that decisively affect the climate [1, 2]. By removing natural vegetation and replacing it with impervious surfaces or without evapotranspiration such as metal, asphalt and concrete, radical changes in surface and atmospheric characteristics of a region are generated [3, 4]. In urban environment consists of two components: natural, which includes the various phenomena and natural elements, such as land cover, geology, air, water, soil and climate unmodified, and artificial that incorporates the social and urban pollution resulting from human activities [5]. These two components altogether positively or negatively affect the lives of city dwellers [6]. The satellite images have brought a new understanding of spatial and temporal variability of urban biophysical surface to increase the quality of environmental data observed and allow repetition of observations in the study area [7]; with this technology it is possible to estimate: emissivity, albedo and elements that cover the surface of the earth as proportions of vegetation, water and rocks. The green area has been extensively studied using the NDVI (normalized difference vegetation index), recognized as one of the most useful in the study of terrestrial biosphere characteristics [8]; being an normalized index it is the variation interval between -1 and 1; where, areas with dense vegetation present positive values. Meanwhile, the water bodies have a tendency to own negative values. Lastly, rocks and bare soil possess a similar spectral response of near-infrared and visible bands, obtained by values approaching to 0 [9].

Some of the effects on urban dynamics using satellite imagery commonly studied are the variation of temperatures with infrared bands [10], biophysical

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reconstructions, type of afforestation [11], urban fire risk and the island urban heat [12] among others, which are caused by the accelerated growth of cities without considering sustainability. In particular, the government of Mexico has an interest in this issue, so that there are now programs for higher education institutions where they teach subjects that incorporate the topic of environmental health and concept of sustainability [13]. For this reason, following this example, the objective of this work is to provide useful information to urban planners for Mexicali city, located in an arid area in northwestern México, as a case study for analyzing spatiotemporal changes of biophysical parameters as NDVI, blackbody temperatures and albedo, using Landsat satellite images.

2. Material and Methods

2.1 Study Area

Mexicali is situated in 32°33" north latitude and 115°28" west longitude with an average elevation of 4 m above the sea level. It is located in the farthest part of northeastern Mexico, on the international boundary between Mexico and the United States. It is characterized by an arid climate with extreme thermal variability that exceeds 50 °C in summer, and in winter reaches temperatures below 0 °C [14]. Since 1950 the industry began to settle in this city generating more jobs, and an intense development, where immigration from other states of the country and the world occurs continuously. Its population is 950,000 inhabitants [15]; in 1993, the city covered an area of approximately 91.43 km^2 that expanded in 2011 to 207.91 km^2. The structure of the urban fabric consists of six zones characterized by its functions and land use. The distribution of land use is predominantly residential with 56%, industrial areas account for 7%, commerce and services to 6%, the public green areas correspond to 8%, and storage facilities represent 1%. Another important characteristic is that the roads and infrastructure covers 15% and 7% corresponds to trade-service-industry, activity [16].

2.2 Satellite Images and Preprocessing

The multispectral analysis data for the period 1993-2011 were obtained from the visible, near infrared and thermal five Landsat satellite images, which identified with the code 39-37 (Path and Row, respectively), supplied by two different sensors, images dated April 6, 1993, May 17, 2008 and May 26, 2011 correspond to the TM (Thematic Mapper) with a pixel size of 60 m and 9n UTM reference unit; and images dated May 3, 2000 and May 12, 2003 were taken by the ETM (Enhanced Thematic Mapper) with characteristics of pixel size of 30 m and reference system UTM 11n.

Before beginning the extraction of spectral information it was necessary to perform a pre-processing to match the geometric and radiometric characteristics (Table 1). It established the same coordinate system UTM 11n were subsequently georeferenced using as control points known from five weather stations in Mexicali urban area. Satellite images were resampled by pixel size 30 m × 30 m using nearest neighbors algorithm, then extracted the study area for the perimeter of the city using urban contour mask of 2011 to each image. Every digital processing was performed using the geographic information system Idrisi Andes.

2.3 Estimation of the NDVI

Once defined the work area, we calculated the rate of NDVI, that is a better measure of physiological activity

Table 1 General characteristics of the Landsat images 1993, 2000, 2003, 2008 and 2011.

Reference system	No. lines columns and unit	Coordinate Top left	Coordinate Bottom right
UTM11N Wgs84	594 lines (m)	X = 631,570	X = 659,375
	927 columns (m)	Y = 3,618,454	Y = 3,600,637

in plants [17]; NDVI was applied to monitor the quality of the environment and its changes; expressed as the ratio of the difference between spectral reflected near-infrared band and visible band and the sum of both (Eq. (1)):

$$NDVI = (NIR - VIS)/(NIR + VIS) \quad (1)$$

where,

NIR = near-infrared band;

VIS = visible band.

2.4 Estimation of the Black Body Temperature

The signals received by the sensors are converted to thermal radiance (L_λ), and the radiance values are converted to brightness temperature blackbody by applying the algorithm (Eq. (2)) included in the software Idrisi Andes.

$$Ts = \frac{k_2}{\ln\left(\frac{k_1}{L_\lambda}+1\right)} \quad (2)$$

where,

L_λ = blackbody radiance;

K_1 = calibration constant, to 607.76 $Wm^{-2}\cdot sr^{-1}\cdot \mu m^{-1}$ Landsat 5 and 666.09 $Wm^{-2}\cdot sr^{-1}\cdot \mu m^{-1}$ to Landsat 7;

K_2 = calibration constant, to 1,260.56 °K to Landsat 5 and 1,282.71 °K to Landsat 7.

2.5 Temporal Analysis of Biophysical Parameters

To know the change in the biophysical parameters, the resulting image set is applied as a TSA (time series analysis) and PCA (principal components); this technique is useful in remote sensing studies because the adjacent bands in a multispectral image are generally correlated [9]. The presence of correlation between these bands implies that there is redundancy in the data, eliminating the correlation between bands, and the new bands created are mutually orthogonal, which are linear combinations of the original ones and are called PC (principal components) [9]. The PC1 (principal component 1) was associated with reflectivity or albedo, while PC2 (principal component 2) was associated with vegetation. Fig. 1 presents a summary of this methodology.

3. Results and Discussion

The TSA was made with a series of images, related to the percentage of the city vegetation. The results indicate a negative trend of 3.76% in the positive values close to one of NDVI with an R2 of 0.81 (Fig. 2). In 1993 we had a 20% vegetation in Mexicali, while for 2000 the change in ground cover plant undergoes a

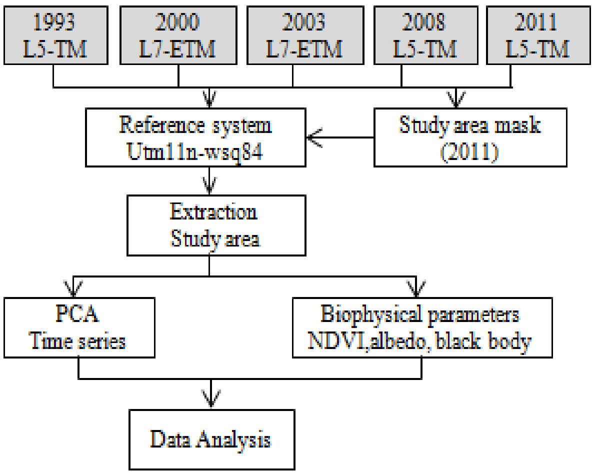

Fig. 1 Methodology summary diagram.

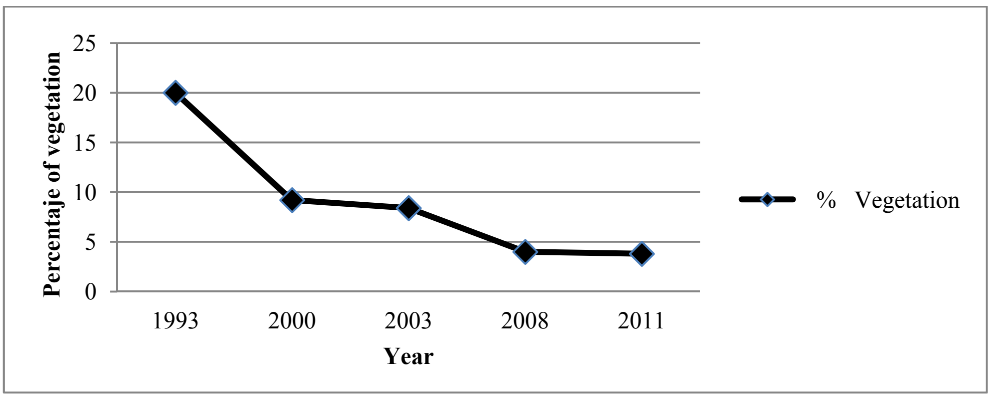

Fig. 2 Percentage distribution of vegetation in Mexicali during years 1993, 2000, 2003, 2008 and 2011.

drastic decrease to 9.2%. In the following three years (2003) the green area coverage had decreased to 8.4%; in 2008, the percentage was only 4.0%, and finally by 2011 the total percentage of vegetation was 3.8%.

Therefore, due to urbanization, urban green areas especially peri-urban land cover Mexicali, had a marked decrease. Urban growth has modified the native biophysical parameters in the study area directly affecting the natural radiative balance [18].

Fig. 3 displays a collection of NDVI for the years 1993, 2000, 2003, 2008 and 2011. The PCA applied to NDVI exhibits significant variations in the first two principal components (PC1 and PC2) due to change of albedo distribution of vegetation within the study area, specifically in the periphery.

During the year 1993 (Fig. 3a), the highest values of NDVI correspond to an agricultural land around or even within the city as well as some sports areas. During 2000 (Fig. 3b), the agricultural area decreased in proportion to urban growth, and the vegetation located in the central part was reduced. In 2003 (Fig. 3c); lowest NDVI values are appreciated in most of the study area, since scarce vegetation located in the surroundings, especially in the south and east of the city near a body of water is noted. In contrast to previous years, in 2008 and 2011 (Figs. 3d and 3e), generally in low density

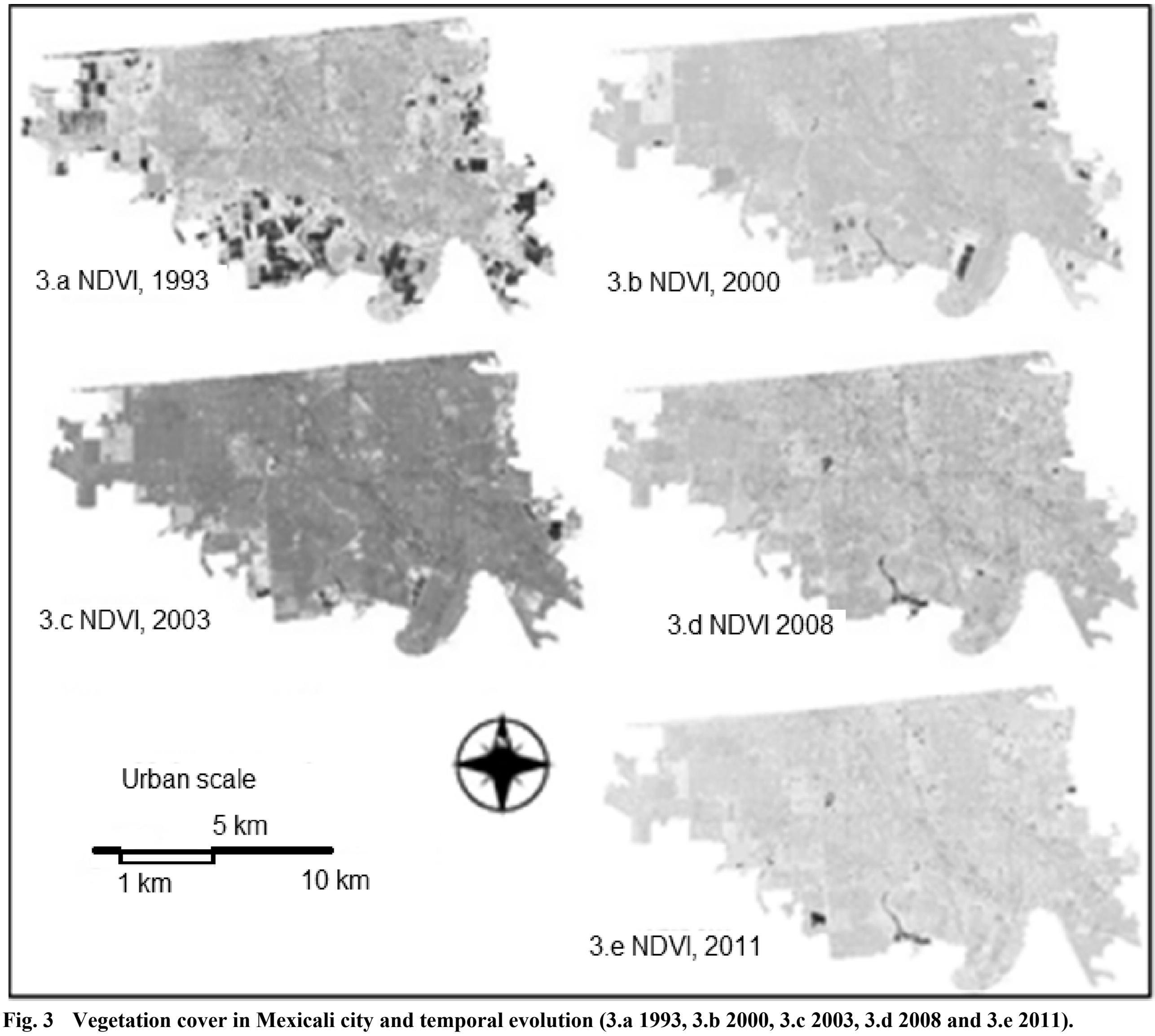

Fig. 3 Vegetation cover in Mexicali city and temporal evolution (3.a 1993, 3.b 2000, 3.c 2003, 3.d 2008 and 3.e 2011).

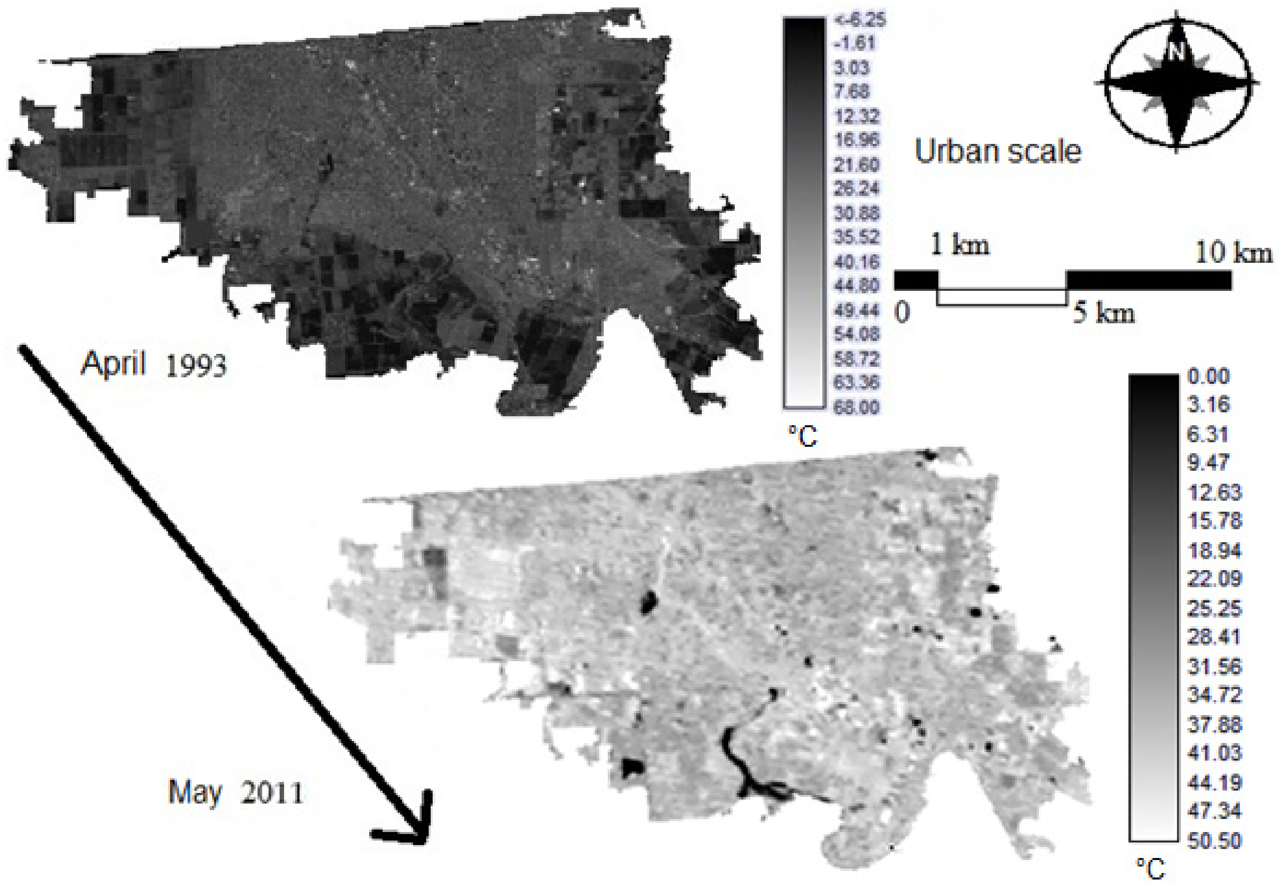

Fig. 4 Blackbody temperature in Mexicali, April 1993 and May 2011.

urban fabric of vegetation is observed which is located principally in parks, sports areas and city forest, therefore, the overall albedo for 2011 was affected as indicated by the CP1 with increased variability of 0.37% compared to 1% (1993), indicating that black body temperature has changed since the first two principal components (PC1 and PC2) account for about 89% of the total variance [19].

In 1993, a range in BT (blackbody temperatures) (Fig. 4), has a higher percentage of vegetation intra and peri-urban areas, where lower BT are located in the surroundings and the highest BT is in the city center (from 34.0 °C to 52.0 °C). In 2011 image shows a more homogeneous distribution, the BT behavior has changed significantly, and while the maximum values are an order of magnitude similar to the year 1993, the thermal range for the urban center is from 41.0 °C to 50.5 °C. Many areas of bare or sparsely vegetated land have changed urban elements (houses, asphalt, pavement, etc.), Therefore, some thermal properties such as heat capacity, admittance, diffusivity and conductivity are significantly altered so that the heat gained by urban surfaces is greater than in vegetation areas.

The behavior of the environmental indicator was analyzed; NDVI and blackbody temperature evidence an inverse relationship was found, e.g., higher levels of vegetation index exist, BT lower and vice versa, lower NDVI, higher BT. This behavior is similar to the Guangzhou city, despite having a subtropical climate [20]. The increase in air temperature has a strong impact on desert cities, to augment at a rate of 1.5% and 2% of energy consumption [21]. In Phoenix, USA, initiatives environmental strategies and legislation for governments were taken into account; the environmental adverse effects are caused by

urbanization and climatically sustainable city back [22]. In other socioeconomic context, the most appropriate mitigation strategies in Mexicali, of green roofs appear to be followed by reforestation, currently applied as a townsman urban corridors to reduce anthropogenic heat [16].

4. Conclusions

The percentage of vegetation in Mexicali has decreased at an accelerated rate in 1993 from 20% to 3.8%. In 2011, the CP1 reveals a change in albedo of 0.37 respect to first image of 1993 that was 0.96 and this is indicative of major change of vegetation to a urban materials. The spatial study of blackbody temperatures in 1993 shows low BT city limits, because of the then existing agricultural areas, while high values of BT are grouped in the downtown; for 2011 BT high values changed their behavior when distributed homogeneously.

Results reveal a change in the biophysical parameters relative to the growth in the city, the area that is modified in the periphery due to the removal and vegetation cover change by different urban elements.

The cartography generated in this evaluation provides the basis for generating more detailed studies to evaluate other biophysical parameters, such as the actual surface temperature, for the convenience of urban planners, to take into account the environmental degradation caused by the growing development while promoting sustainable policies.

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Wastewater Quality Assessment of a Petroleum Refinery in Ghana

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Abstract: TOR (Tema oil refinery) is the only petroleum refinery in Ghana. To assess the quality of the wastewater, wastewater samples taken from three points of discharge into the treatment plant and the treated effluent were analyzed for physico-chemical characteristics. The levels of the pH, temperature, conductivity, COD (Chemical Oxygen Demand), TDS (Total Dissolved Solids), TSS (Total Suspended Solids) and phenol were assessed from January to June, 2011. The results obtained indicate varied levels of contaminants in both the untreated and treated wastewater. The average values of the treated effluent parameters analyzed were 38 °C, 6,258 $\mu s \cdot cm^{-1}$, 314 $mg \cdot L^{-1}$, 115 $mg \cdot L^{-1}$, 2,689 $mg \cdot L^{-1}$ and 1 $mg \cdot L^{-1}$ for the temperature, conductivity, COD, TDS, TSS and phenol, respectively. The results suggest that both the raw wastewater and the treated effluent did not meet the discharge limit set by Ghana Environmental Protection Agency. Therefore, the treated effluent required additional treatment before it can be discharged into the environment. This suggests that the wastewater treatment plant of TOR is ineffective for the type of wastewater produced.

Key words: Industrial wastewater, petroleum, effluent, pollutants, Tema oil refinery, Ghana.

1. Introduction

Water is a cross-cutting element of the GPRS II (Growth and Poverty Reduction Strategy II) of the Republic of Ghana, and is linked to all eight of the MDGs (Millennium Development Goals) [1]. Environmental pollution by industries is however a major problem threatening the achievement of these goals. Due to the ineffectiveness of some purification systems, wastewaters may become hazardous, leading to the accumulation of toxic products (such as heavy metals, benzene, toluene, ethylbenzene, xylene and phenol) in the receiving environment with serious consequences on the ecosystem [2].

The petroleum industry is a major contributor to environmental pollution. Petroleum refinery effluents are priority pollutants due to their high polycyclic aromatic contents, which are toxic and tend to be more persistent in the environment [3, 4]. Decreased productivity of algae, a very important link in the food chain, observed for receiving water bodies has been attributed to the harmful effects of these contaminants [5, 6]. Field studies have also established that oil refinery effluents often have an impact on the fauna, which is usually restricted to the area close to the outfall [7].

Environmental and safety concerns indicate that oil refineries must be located some distance away from major urban areas; nonetheless, there are many instances where refinery operations are close to populated areas and pose health risks. The TOR (Tema oil refinery) is no exception. One of the numerous processes that lead to the conversion of crude oil into fuel is the boiling of the crude and the application of sea water as a coolant to remove heat

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from the crude. The resultant heated sea water is discharged, without any pre-treatment, directly into the Chemu lagoon. According to Ghana Environmental Protection Agency, the refinery discharges about 50 million gallons of heated sea water at 61 °C into the lagoon daily, which is considered too high to support any aquatic life [8].

In many developing countries, industries dispose of their effluents without adequate characterization, quantification and treatment due to lack of adequate legislation and law enforcement, as well as due to economic and technological constraints [9-11]. An important step in the selection of a treatment system is to study the physical and chemical characteristics of the wastewater stream in question [12]. The study of a wastewater stream's characteristics will help to identify the types and concentrations of contaminants present in the wastewater and provides information on the treatment required to meet the regulatory limits for discharge.

The objective of this study was to characterize the wastewater of TOR, thereby generating reliable data for adequate management of the effluent. This work therefore assessed the levels of physico-chemical parameters of both the influents to the treatment plant and the treated effluent to determine the extent of contamination and hence the level of compliance with the regulatory limits of the Ghana EPA (Environmental protection agency) for industrial effluent disposal.

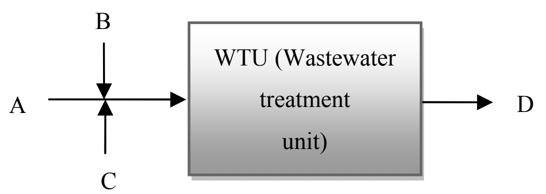
2. Materials and Methods

2.1 Study Area and Profile of TOR

The TOR (Tema Oil Refinery) in Tema, Ghana, is a vital element in Ghana's economy, supplying refined fuel for the country's automobiles and airlines as well as kerosene and LPG (Liquefied-petroleum gas) for domestic and industrial use. TOR is located at about 40 km from Accra, the capital of Ghana. It is the only crude oil refining plant in the country. The refinery which has a distillation capacity of 45,000 bpd (barrels per day) is owned by the Government of Ghana. Tema Oil Refinery was established in 1963 with a distillation capacity of 25,000 bpd. This was upgraded to 45,000 bpd in 1997 by a South Korean consortium led by Sunkyong and Samsung Engineering of South Korea. The refinery's crude oil supply is imported from Nigeria. A second-phase modernization completed in 2002 has allowed the refinery to use residues of fuel oil to be reconverted into gasoline and LPG. Currently, the refinery is operating under capacity and is unable to meet all the fuel requirements of the country. Tema oil refinery's processing activities involve the use of substances, and the generation of by-products which could be harmful to the environment. A treatment plant treats part of the effluent produced. The characteristics of the refinery's effluent (treated and untreated) were assessed to determine the level of contamination and compliance with the Ghana EPA standards [13]. Fig. 1 is a simplified diagram of the effluent treatment plant showing the sampling points.

2.2 Wastewater Sampling

Samples were collected weekly from January 2011 to June 2011. Sampling, sample preparation, documentation and sampler cleaning were performed in accordance with procedures prescribed in APHA (American Public Health Association) [14]. Wastewater samples were collected with a 2 L plastic hydro bios water sampler after being rinsed thoroughly with deionized water followed by



A: Wastewater from the CDU (crude distillation unit);
B: Wastewater from the upstream;
C: Wastewater from the T-bridge;
D: Treated effluent discharge.

Fig. 1 A simple flow diagram of the wastewater treatment unit showing the three main sources of influent.

wastewater sample. This wastewater was then transferred to well-rinsed 1 L polyethylene containers and 250 mL capacity borosilicate glass bottles. Wastewater samples were collected from the CDU (crude distillation unit), TB (T-bridge) and US (upstream), prior to the treatment plant; and from the WWTU (Wastewater treatment unit) discharge point. All samples were transported in ice chests for analysis within 12 h after collection.

2.3 Wastewater Characterization

2.3.1 Analytical Quality Assurance

For all the methods that required the use of the spectrophotometer, both reagent blanks and sample blanks were used. The purpose of using blanks was to negate the effect of background interferences. When the absorbance was not zero for a particular parameter, the value was subtracted in order to obtain accurate determination of the parameter concerned. By blanking the instrument, it was assured that any reading obtained was exclusively due to the component of interest and not due to irrelevant chemicals in solution. Standard solutions were prepared for the COD (Chemical Oxygen Demand) analysis. Before any measurement was done, instruments were calibrated using standard solutions. All field meters and equipment were checked and calibrated according to the manufacturers' specification. Preservation and handling of samples were done in accordance with procedures described in APHA (American Public Health Association) [14]. All analyses were performed in triplicate.

2.3.2 Wastewater Analysis

In characterizing the wastewater, samples were taken from streams A, B, C and D (Fig. 1) for the determination of the following parameters: pH, temperature, conductivity, COD, TSS (Total Suspended Solids), TDS (Total Dissolved Solids) and phenol. Temperature, pH, conductivity and TDS of the samples were determined onsite using a multi-parameter ion specific meter (Hanna instrument, combo), while the TSS was measured in the laboratory using a HACH spectrophotometer (DR/2000). The COD and phenol were determined in the laboratory according to procedures described in the standard methods for the examination of water and wastewater [14].

2.4 Statistical Analysis

Standard statistical analysis was conducted using Excel and the Statistical Package for the Social Sciences (SPSS 17.0) software for windows [15, 16]. The SPSS software was used to perform DSA (Descriptive Statistical Analysis) of the data.

3. Results and Discussion

3.1 Descriptive Statistics of the Wastewater Characteristics

In line with the objectives of this study, the values of contamination indicators of both the influents to the wastewater treatment plant and the treated effluent were analyzed in order to ascertain the pollution load and to establish the level of compliance with the Ghana Environmental Protection Agency standards [13]. The results of the descriptive statistical analysis of the data are shown in Table 1. This study showed that most of the indicator values of the wastewater did not meet the permissible limits set by the Ghana Environmental Protection Agency [8, 13] for industrial effluent and the WHO (World Health Organization) guidelines for use of wastewater in agriculture and aquaculture [17].

3.2 Variations in Wastewater Characteristics

3.2.1 pH

It can be observed from Fig. 2 that the pH values of Upstream and treated effluent varied from 6.6-8.3, and were within the regulatory permissible range of 6 to 9 [8] throughout the study period. However, that of the T-bridge and the CDU recorded values higher than 9 in the beginning of the study period, but dropped to the acceptable range towards the end of the first

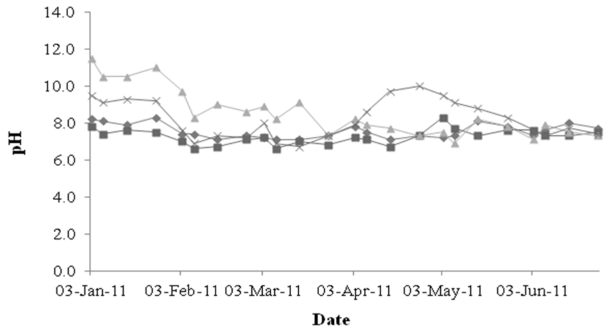


Fig. 2 Variations in pH of the wastewater measured between January 2011 and June 2011 for upstream (♦), CDU (■), T-bridge (▲) and WTUDP (x).

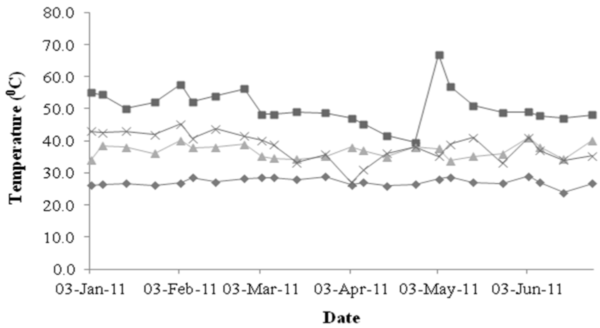


Fig. 3 Variations in temperature of the wastewater measured between January 2011 and June 2011 for upstream (♦), CDU (■), T-bridge (▲) and WTUDP (x).

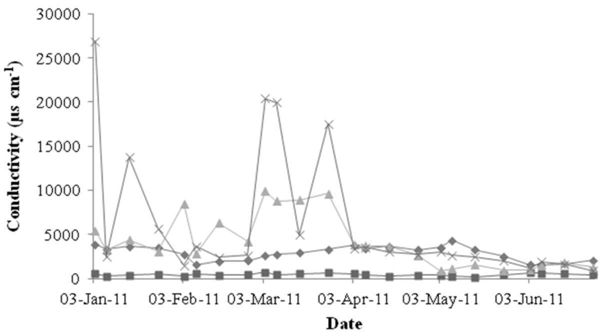


Fig. 4 Variations in conductivity of the wastewater measured between January 2011 and June 2011 for upstream (♦), CDU (■), T-bridge (▲) and WTUDP (x).

month of study. It can be observed that the pH of the treated wastewater at the discharge point of the treatment plant (Fig. 1) varied between 6.6 and 8.3 (Fig. 2). These values are within the permissible range, suggesting that the treated effluent has the right pH for discharge into the environment.

3.2.2 Temperature

Fig. 3 shows the variation in temperature at each of the sampling points measured. The highest temperature recorded was 67 °C at the CDU (Table 1). Generally, the temperatures of the wastewater from the CDU were high, averaging 51 °C during the study period. However, the T-bridge and upstream wastewater temperature varied from 33.8 °C to 41 °C and 24 °C to 29 °C (Table 1), respectively. These values were generally within the regulatory standard of 40 °C [8]. Most importantly, the temperature of the treated effluent (Table 1) was slightly above 40 °C for the first two months of study. This could be attributed to the high temperature of the CDU recorded during that period. In cases where the treated effluent's temperature exceeds the permissible limit, further cooling should be done before discharge into the receiving water body so as to preserve aquatic life.

3.2.3 Conductivity

Fig. 4 shows the variation in the conductivity values of the wastewater studied. Indeed, the wastewater from the CDU did not meet the EPA specification, recording values above the regulatory standard of 750 $\mu s \cdot cm^{-1}$ [8]. In fact, only the treated effluent has the right value of conductivity required for effluent discharge into the environment. It can, however, be observed that the conductivity of the T-bridge varied quite widely from 896 $\mu s \cdot cm^{-1}$ to a maximum value of 9890 $\mu s \cdot cm^{-1}$ (Table 1), between the months of January and April. Nonetheless, it began to decrease from about 3,000 $\mu s \cdot cm^{-1}$ in April to values below the EPA maximum permissible value in May and throughout the rest of the study period. The conductivity of the treated effluent also showed significant fluctuation over the study period, with values ranging between 132 $\mu s \cdot cm^{-1}$ and 702 $\mu s \cdot cm^{-1}$ (Table 1). These values are acceptable for effluent discharge.

3.2.4 COD

The COD of the upstream effluent for treatment as can be observed (Fig. 5) varied slightly from 30 to 194 but less than the maximum permissible level of 250 [8]. However, the effluents from the CDU and T-bridge prior to treatment recorded average COD value which was above the maximum regulatory limit (Table 1). Fig. 5 shows that after the treatment, the

Table 1 Descriptive statistics of the tailings dam wastewater characteristics.

Parameters	Range	Mean	GH EPA standards
Upstream			
pH	7.1-8.3	-	6-9
Temperature (°C)	24-29	27.3 ± 1.2	40
Conductivity ($\mu s \cdot cm^{-1}$)	1546-4334	2,858 ± 837	750
COD ($mg \cdot L^{-1}$)	30-194	84 ± 45	250
TDS ($mg \cdot L^{-1}$)	9-54	27 ± 13	50
TSS ($mg \cdot L^{-1}$)	775-1954	1,565 ± 363	1,000
Phenol ($mg \cdot L^{-1}$)	0.43-3.8	1.5 ± 0.8	2
CDU			
pH	6.7-10	-	6-9
Temperature (°C)	40-67	51 ± 5.6	40
Conductivity ($\mu s \cdot cm^{-1}$)	877-26,900	6,258 ±7 ,408	750
COD ($mg \cdot L^{-1}$)	92-1256	314 ± 277	250
TDS ($mg \cdot L^{-1}$)	16-474	115 ± 22	50
TSS ($mg \cdot L^{-1}$)	757-13600	2,689 ± 3,493	1,000
Phenol ($mg \cdot L^{-1}$)	0.01-2.01	1 ± 0.5	2
T-bridge			
pH	6.9-11.5	-	6-9
Temperature (°C)	33.8-41.0	36.9 ± 2.1	40
Conductivity (µs/cm)	896-9,890	4,127 ± 2,993	750
COD ($mg \cdot L^{-1}$)	194-941	670 ± 245	250
TDS ($mg \cdot L^{-1}$)	29-233	127 ± 61	50
TSS ($mg \cdot L^{-1}$)	132-4,970	1,862 ± 1,615	1,000
Phenol ($mg \cdot L^{-1}$)	0.01-1.53	0.67 ± 0.2	2
Treated effluent			
pH	6.6-8.3	-	6-9
Temperature (°C)	27-45	38 ± 4.5	40
Conductivity ($\mu s \cdot cm^{-1}$)	132-702	438 ± 35	750
COD ($mg \cdot L^{-1}$)	35-158	72 ± 29	250
TDS ($mg \cdot L^{-1}$)	8.2-48.5	22 ± 12	50
TSS ($mg \cdot L^{-1}$)	789-1,687	1,361 ± 224	1,000
Phenol ($mg \cdot L^{-1}$)	0.5-5.2	2.5 ± 0.7	2

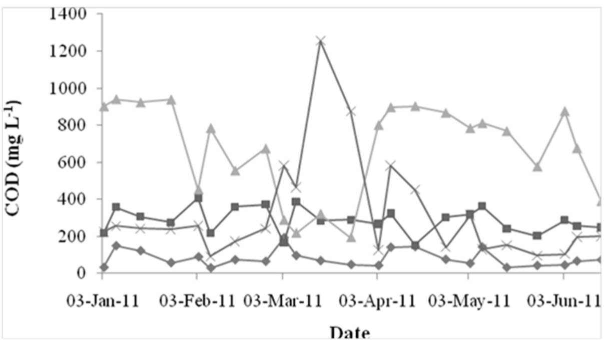


Fig. 5 Variations in COD of the wastewater measured between January 2011 and June 2011 for upstream (♦), CDU (■), T-bridge (▲) and WTUDP (x).

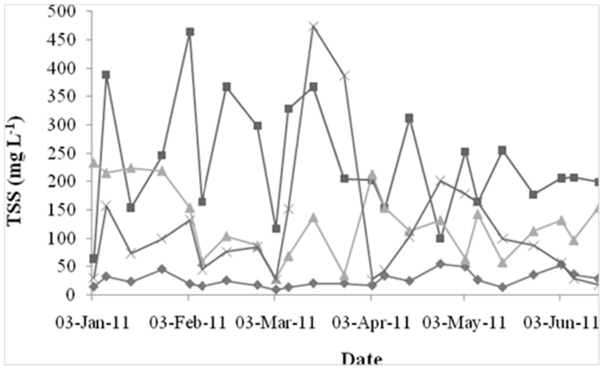


Fig. 6 Variations in TSS of the wastewater measured between January 2011 and June 2011 for upstream (♦), CDU (■), T-bridge (▲) and WTUDP (x).

COD values recorded were below the maximum regulatory limit.

COD is an important parameter commonly used to examine wastewater quality since it reflects the organic load in wastewater. The very high levels of COD recorded for March suggest high levels of chemical contamination.

3.2.5 TSS

With respect to the total suspended solids, the average values calculated (Fig. 6) for all the streams were above the Ghana EPA standard and WHO guideline value of 1,000 $mg \cdot L^{-1}$ [8, 17]. The high TSS values after treatment may be attributed to the high TSS contained in the wastewater from the CDU and T-bridge (Table 1). Consequently, secondary treatment of the treated effluent with respect to this parameter is needed before discharge into the environment.

3.2.6 TDS

The variation in TDS of the wastewater measured during the study period is shown in Fig. 7. The average TDS of the wastewater from the CDU and the T-bridge (Table 1) were 115 $mg \cdot L^{-1}$ and 127 $mg \cdot L^{-1}$, respectively. These values are above the maximum regulatory permissible level of 50 $mg \cdot L^{-1}$ [8]. The TDS of the treated effluent, on the other hand, met the Ghana EPA discharge requirement. These high values of TDS could be as a result of high concentration of inorganic salts like carbonates, bicarbonates, chlorides, sulphates and as well as small amounts of organic

matter and dissolved gases in the treated effluent. It could also be due to high volumes of wastewater produced during that period. With respect to TDS, no secondary treatment is needed to further treat the effluent from the treatment plant.

3.2.7 Phenol

The level of phenol in the wastewater from T-bridge before treatment (Fig. 8) was below the maximum regulatory permissible level of 2 mg·L^{-1} [8] throughout the study period. Furthermore, apart from two phenol values which were above 2 mg·L^{-1}, all the rest were below it. The phenol level in the upstream wastewater was relatively high at the beginning of the study period, recording a value of about 3.8 mg·L^{-1}, but decreased till the beginning of February where it began to fluctuate between 0.5 mg·L^{-1} and about 2.2 mg·L^{-1}. On the other hand, as is desired, the phenol level in the treated effluent at the discharge point of the WTU was generally below 2 mg·L^{-1}. This suggests that the treatment plant is efficient in reducing phenol levels in the wastewater, which is very significant since this pollutant is very toxic and therefore not friendly in the aquatic environment [3, 4].

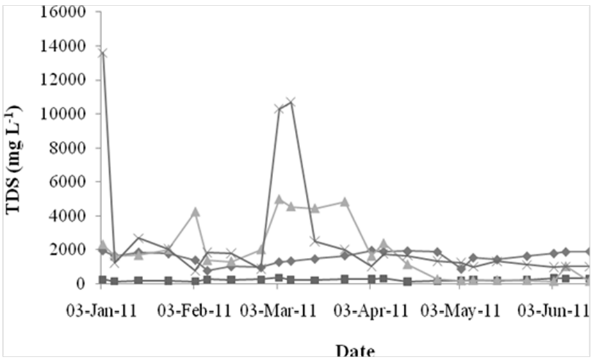


Fig. 7 Variations in TDS of the wastewater measured between January 2011 and June 2011 for upstream (♦), CDU (■), T-bridge (▲) and WTUDP (x).

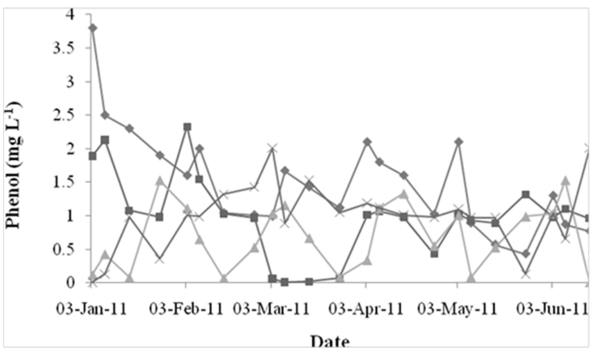


Fig. 8 Variations in phenol concentration of the wastewater measured between January 2011 and June 2011 for upstream (♦), CDU (■), T-bridge (▲) and WTUDP (x).

4. Conclusion

Based on the results obtained, it can be concluded that:

(1) The pH, temperature, TDS and phenol levels of the treated effluent met the Ghana Environmental Protection Agency's regulatory standards;

(2) The remaining pollutants, namely, conductivity, COD and total suspended solids however exceeded the regulatory limits;

(3) The study showed that the wastewater treatment plant of the Tema Oil Refinery is not capable of meeting the Ghana EPA discharge requirement for all the pollutant. Consequently, an additional treatment step is needed to make the treated effluent safe for discharge into the environment.

Acknowledgments

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Can Lithium Energize Sustainable Development in Bolivia? Institutional and Policy Challenges

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Abstract: A new extractive boom looms over Bolivia, home to roughly a third of the world's lithium reserves. Since previous mining booms have not put the country on a sustainable development path, this paper briefly outlines the initial results of a research on policy options to break away with the past. The paper first assesses the relationship between resource dependence and sustainable development by looking at the evolution of genuine savings in Bolivia and neighbouring, resource-rich countries. It then discusses Bolivia's potential position on the world's lithium market and examines the institutional variables that shape perceptions, expectations and policy options at national and local levels. Notwithstanding major technological challenges, the paper concludes that further research should shed light on how inclusive processes can be nurtured in rentier states, and how far specific institutional reforms can contribute to turning the looming lithium boom into sustainable outcomes in the Bolivian case.

Key words: Bolivia, lithium, new institutional economics, resource curse, human capital, genuine savings.

1. Introduction

Lithium has become a strategic resource, notably for the production of lithium-ion batteries for electric vehicles whose demand is booming in East Asia and elsewhere. Bolivia is said to possess the largest reserves, holding about a third of the world's deposits [1]. This offers a great opportunity to spur economic diversification and put Bolivia on a sustainable development path. Yet, history calls for caution. When considering the outcome of previous extractive booms, there is ample evidence that Bolivia tends to fall prey to the so-called "resource curse", be it in the case of silver from the 16th century onward, guano/nitrates between 1850 and 1880, rubber at the turn of the 20th century, or fossil fuels since the 1930s. Recent empirical literature shows that while the resource curse tends to affect many resource-rich fragile states, other developing countries have succeeded to turn extractive booms into more sustainable patterns of economic growth and development. Can Bolivia succeed in turning a looming lithium boom into sustainable development? What are the major determining variables? What lessons can be drawn from neighbouring countries?

2. Methodological Approach

Genuine savings often serves as an indicator of weak sustainability to assess the relationship between resource dependence and development. The World Bank has defined and calculated genuine savings schematically as follows:

$$ANS = GS - Depr + EE - NRD - CDE \quad (1)$$

where, ANS stands for adjusted net savings, which consists of GS (gross savings) net of capital Depr (depreciation), augmented by EE (education expenditure) minus the rent from NRD (natural resource depletion) and CDE (carbon dioxide

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emissions). It builds on Hartwick's rule that a country's total capital stock should at least maintained constant over time, whereby the rent accruing from the exploitation of non-renewables should be reinvested in physical and human capital.

A comparative assessment of ANS as a percentage of GNI (gross national income) reveals that the greater the resource dependence (exports as % GNI), the less stable the ANS. ANS remains remarkably stable in Switzerland, a typically resource-poor country. Fig. 1 further shows that Bolivian ANS rates fluctuated around zero, whereby the economy has been barely able to compensate for the depletion of non-renewable resources. Botswana stands out: the country follows a more sustainable development trajectory. This results from prudent fiscal management based on the "sustainable budget index", whereby the extractive rent must be reinvested in the economy and cannot serve to finance current government expenditure [2].

Fig. 2 shows that investment in human capital has been crucial in compensating natural resource depletion and the mostly negative investment in physical capital [3]. Yet, investment in human capital as a share of GDP (gross national product) appears highly sensitive to extractive cycles. In the case of Bolivia, mineral extraction booms in terms of volume tend to produce superior outcome than price booms when considering education expenditure as a share of GDP [3].

The key question hence is how to effectively channel the extractive rent into the education and productive sectors. This requires looking into the specific institutional context that has characterized the extractive sector and its position within a resource-rich country such as Bolivia. In short: history and institutions matter a great deal [4]. Capturing institutional variables and measuring their impact remain a daunting challenge for social scientists. In what follows, the authors shall focus on the case of Bolivia.

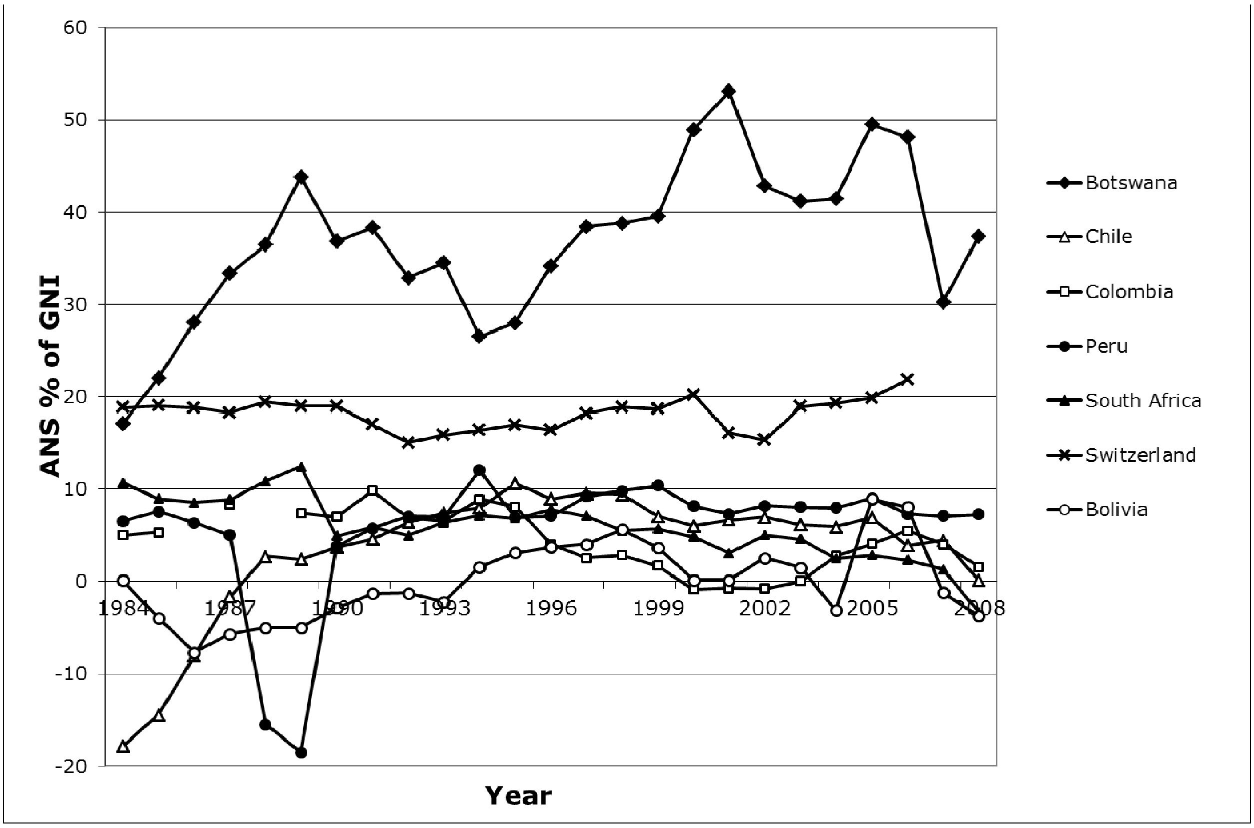

Fig. 1 Evolution of ANS in selected resource rich countries and Switzerland.

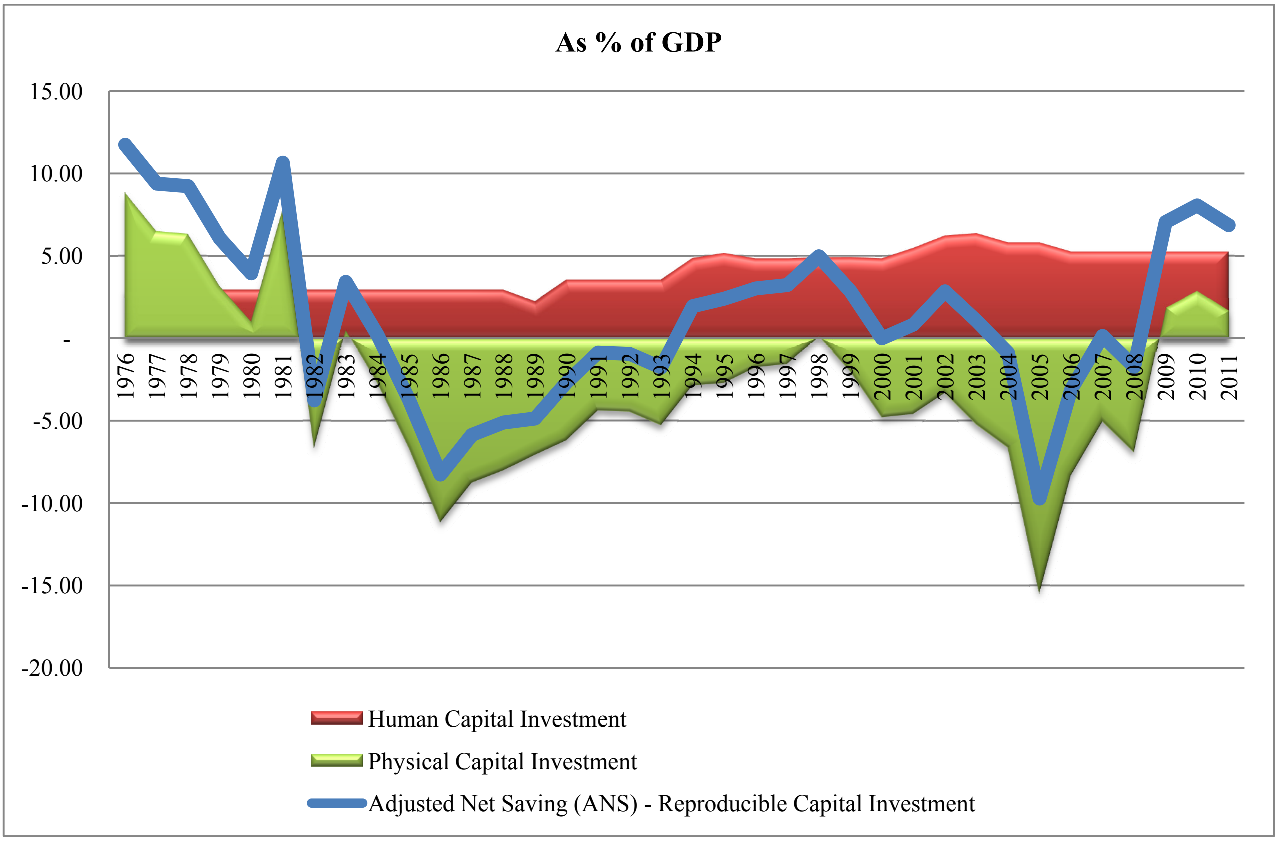

Fig. 2 Bolivian ANS and its components (net investment in physical and human capital) [3].

3. Case Study

Bolivia's Salar de Uyuni is said to contain about one third of the world lithium resources and is thus the world largest resource deposit yet to be exploited. The salt flat covers an area of 10,582 km^2 located 3,660 m above sea level. The Salar's brine has been formed over millennia through annual flood and evapotranspiration cycles resulting in the accumulation of lithium, magnesium and potassium. Uyuni brines have a relatively low average lithium concentration, about 0.05% compared to other brine's concentrations that can reach up to 0.68%. Low concentration together with local environmental conditions (e.g., humidity, evapotranspiration rates) shall increase production costs and renders competitive market entry more challenging.

After a failed attempt to attract foreign direct investment at the beginning of the 1990s, the Bolivian government has now set up plan drawing on domestic investment and technology development. The pilot phase (2012-2015) aims at the production of lithium carbonate and potassium chloride. The second phase (2016-2017) aims at industrial production of both minerals, and the third phase (2016-2020) foresees moving up along the value chain with the production of li-ion batteries in Bolivia. The incumbent government takes pride in stating that lithium production will be developed by Bolivians based on locally-produced technology. Collaboration with foreign partners is foreseen in the third phase, which requires higher technology transfers. Yet, delays in the initial phase combined with limited information made public have led to heavy criticisms and a heated domestic debate on the feasibility and adequacy of the government's plan. Some argue that Bolivia will not be able to succeed without foreign investment and technology and that the country misses a time-bound opportunity while worldwide demand may soon diminish with the emergence of alternative battery

technology and improved lithium recycling.

There is no consensus on whether lithium supply will be short or not in the coming years. Worldwide lithium reserves have been estimated between 35 Mt (million tonnes) and 40 Mt whereas demand over the coming decades may not exceed 20 Mt. Thus, an increasing demand may be met without major price hikes until the end of this century [5]. If prices remain relatively low, the challenge for Bolivia will be to successfully enter such a competitive market despite higher production costs associated with less favourable geology, climate and geography than in neighbouring countries.

4. Results and Discussion

The prospect of a lithium boom in Bolivia has raised expectations and spurred a vivid political debate. Because of a wish not to repeat negative experiences with silver, tin and other extractive booms in the past, resource nationalism tends to prevail. The government views the looming lithium boom as an opportunity to promote state-led industrialization, leaving not much space for debate with domestic stakeholders (private sector, civil society organizations, the academic community).

At the national level, the debate focuses on technology and human resources. Production shall be based on domestic technology under state-led initiative, involving a small group of researchers and professionals with little connection to the wider scientific community. Information is limited, leaving room for speculation on the extent to which the project will be a success and how far scientific collaboration with foreign partners (Japan, South Korea) is being pursued. In view of the industrialization phase, a collaboration shall be established with the Netherlands with a view to training MA and Ph.D. students, leaving public Bolivian universities aside.

Another debate focuses on the allocation of the forthcoming revenues from lithium exploitation. The new Bolivian Constitution states that all minerals are considered strategic resources, which are property of the Bolivian people administered by the state "for the benefit of the population as a whole" (Art. 348). A new mining code is being debated by congress, with expected changes on the property and revenue distribution regimes that shall provide a new institutional framework for lithium extraction.

Research conducted at the provincial and local levels reveals that the local administration and organizations feel that their concerns are not being factored into the design of lithium extraction plans. Their main concerns revolve around economic return and socio-environmental impacts:

The new constitution states that extractive resources and revenues belong to the nation as a whole. The economic benefits for the region and the local population are far from clear while expectations are high, including with regard to job generation and return in terms of fiscal revenue. Interviews reveal that local communities further expect the lithium plant to provide investments in infrastructure and education, following the recent drive by some private firms under corporate social responsibility [6].

Water and other environmental issues have not been addressed so far while it ranks high as a major concern at the local and regional levels. Historically, communities around the Salar de Uyuni have been engaged in pastoralism and agriculture. As a result of higher prices in the face of growing worldwide demand, the dependency on quinoa production is threatened by ground water diversion and contamination associated with mining activities, including those taken by the state-owned mining company Comibol at the lithium pilot plant on the southern tip of the Salar.

Resource extraction has been at the heart of the economic, social and political dynamics of the region since colonial times. Uyuni is located in the Province of Potosi, the capital city of silver extraction in the 16th and 17th centuries. Political and civil society

leaders in Potosi repeated over and again that they do not want to see again the disastrous impact of silver and tin exploitation in the past, and hope that lithium can offer an avenue to depart from former extractive patterns.

Over the last two decades, extractive activities around the Salar of Uyuni have dramatically increased with the establishment of MSC (minera san cristobal), a subsidiary of Japan's Sumitomo Corporation exploiting one of the world's largest zinc deposits. It is the largest private mining corporation in Bolivia [5]. The Comibol lithium pilot plant established near Rio Grande (Llipi) on the southern shore of the salt lake represents the newest extractive large-scale extractive project in the region.

Extractive interests keep contributing to shaping laws, codes and regulations for the benefit of specific interest groups with enough power to stir institutional changes [6], as witnessed in the way MSC which was established and the many adaptations in the delineation of the Salar de Uyuni natural reserve borders to facilitate extractive activities and foreign investment.

The complex and contradictory nature of the current institutional context that regulates extractive activities and allocates the ensuing rent reflects how particular interests have been able to influence formal and informal institutions over time. The mismatch between these institutions and the increasing expectations of local communities and regional authorities is a potential source of conflict that may threaten the long tern viability of a lithium boom breaking away with the resource course pattern affecting Bolivia.

5. Conclusion

Appropriate technology for lithium extraction and industrialization in the Bolivian context is a precondition for the ongoing state-led project to successfully enter the world market in spite of difficult geological and climate conditions. Yet, technical solutions alone are clearly not sufficient to ensure the long-term viability of the project. More importantly perhaps, it will not break away with a history of failed attempts to avert the resource curse. History and institutions matter a great deal. In other words, social capital plays a key role in explaining how far natural capital depletion is compensated by investments in human and physical capital.

There are many ways in which formal and informal institutions influence this process. In the Bolivian case, the challenge involves reforming laws and regulations as well as inclusive deliberation processes. The authors have argued that reinvesting the extractive rent in human capital is a critical dimension of weak sustainability as reflected in constant genuine savings. Extractive booms (resulting in particular from price hikes) have had a negative impact on education expenditure as a share of GNI. This will not change as long as strategic decisions on human capital investments are made by the central state without greater involvement domestic stakeholders including public and private universities.

More broadly, sound institutional processes imply changes in formal rules and procedures dictated by laws and regulations. They also require changes in perceptions and habits embedded in a long history of resource extraction. Top-down policies that emphasize the role of the central state without involving local and national stakeholders may raise the potential for conflict and eventually threaten the success of the ambitious project of lithium-led industrialization. Further research could shed more light on inclusive checks-and-balance mechanisms in rentier states.

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Subsurface Drainage Impact Assessment in Ibshan, Egypt

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Abstract: This paper aims to mitigate the impacts of subsurface drainage system in Ibshan, Egypt on the environment. For studying and analyzing these impacts, data are collected concerning before and after the installation of the subsurface drainage system. The environmental impacts are set to be crops yields, salinity, and water table depth. Concerning crops yields, five crops are identified to study the effect of the subsurface drainage system on their productivity. Regarding salinity, the saline areas are investigated pre and post the subsurface drainage system. For the water table depth, the ground water table depths are reviewed before and after the subsurface drainage system. Also, the DRAINMOD-S computer program is employed to determine the effect of the subsurface drainage system on the water table depth. It is concluded that the environmental impacts of the subsurface drainage system in Ibshan area are very good. The yields of five crops increased from 7% to 38%, 16.4% of saline areas are improved, and the ground water table depth is reduced by 10%. Also, an equation is obtained to predict the percentage decrease of ground water table depth according to the laterals spacing of the subsurface drainage system.

Key words: Subsurface drainage, crops yields, salinity, water table, DRAINMOD-S, Nile Delta.

1. Introduction

Drainage is one of the most effective means to assure the enhancement of soil productivity and sustainability of agriculture for food production. Subsurface drainage is a good tool to achieve this goal.

In Egypt, more than 2 million fed have subsurface drainage systems. These systems have been designed with fixed drain depths and tile spacing to meet certain strict drainage criteria based on conservative design assumptions regarding crop type and rooting depth.

The crop productivity is the final outcome of the interaction of a variety of factors and determinants of natural, economic, social, regulatory, and legislative nature. The natural factors come at the forefront affecting factors on the agricultural production. Whereas, the crop productivity reflects the impact of these factors combined.

The effect of subsurface drainage on crop yield showed an increase in the yields of rice, sugarcane, wheat, sugar beet and tobacco, while the yield of cotton crop was relatively low mainly due to the shortage of irrigation supplies [1].

The effect of subsurface drainage on soil salinity showed that the surface and profile salinities were significantly decreased by 20% and 14%, respectively with respect to the pre-project [2].

The benefits of subsurface drainage systems were associated with negative impacts such as pollution of drainage water with salts, nutrients, organic components, and harmful minor elements like heavy metals [3].

DRAINMOD-S and SWAT (soil and water assessment tool) are two popular water table

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management models developed to predict drain flow rates [4]. A finite difference solution of the Richards's equation is employed by a simulation model of the SWAT, while the Hooghoudt and Kirkham equations in terms of mid-space water table elevation between drains are followed by DRAINMOD-S.

The rate of water movement into drains depends on the hydraulic conductivity of the water flow domain of the surrounding soil, drain spacing and depth, soil profile depth, and water table elevation.

DRAINMOD-S model was evaluated under semi-arid conditions in Maruit in the western delta of Egypt for three cropping seasons [5]. The reliability of the model was evaluated by comparing measured and predicted values of the daily ground water table depth, cumulative outflow based on total monthly outflow, soil salinity during each season, and relative crop yield. Good agreements were found between the measured and predicted values.

This paper aims to mitigate the impacts of subsurface drainage system in Ibshan, Egypt on the environment. Ibshan area is located in northeastern part of the Nile Delta 120 km away of Cairo.

The area is approximately 5,000 feddans. This area has been selected based on its wide range of geo-hydrological, climatic and socio-economic conditions as well as availability of soil salinity data. The subsurface drainage system in Ibshan area was constructed by EPADP (Egyptian Public Authority for Drainage Projects) since 1995. The design of the subsurface drainage system was made according to the standard criteria of EPADP. The drains depths are 1.50 m for laterals and 2.5 m for collectors. The spacing between laterals is 60 m.

2. Analyses of the Data

In this paper the environmental impacts are set to be crops yields, salinity, and water table depth. For studying and analyzing these impacts, data are collected concerning before and after the installation of the subsurface drainage system. The collected data are first screened for their integrity, and then are analyzed to assess the efficiency of the subsurface drainage system with respect to the above stated environmental impacts.

For the first environmental impact concerning crops yields, five crops are identified in Ibshan area to study the effect of the subsurface drainage system on their productivity. In the summer season the crops are cotton, maize, and rice. While in the winter season the crops are wheat and beans. It has to be mentioned that these crops are very important in Egypt. They represent 60% of the total cultivated area, and they are the most famous import and export crops that affect greatly the Egyptian national economy.

For the second environmental impact concerning salinity, the saline areas in Ibshan are investigated pre and post the subsurface drainage system.

For the third environmental impact concerning the water table depth, the ground water table depths in Ibshan are reviewed before and after the subsurface drainage system. Also, the DRAINMOD-S computer program is employed to determine the effect of the subsurface drainage system on the water table depth in Ibshan. Observation points are selected all over the area of the subsurface drainage system in Ibshan. These points are located at distance of 100 m from the canals or drains, and at distance of 70 m-120 m from the collectors. The distance between each two observation points is 400 m-500 m.

3. Results and Discussion

For the first environmental impact concerning crops yields, five crops are identified in Ibshan area to study the effect of the subsurface drainage system on their productivity. In the winter season the crops are wheat and beans. While in the summer season the crops are rice, cotton, and corn. It has to be mentioned that these crops are very important in Egypt.

In Ibshan area, the average yields pre the subsurface drainage system (1990-1995) and post the subsurface drainage system (1996-1998) for the five major crops

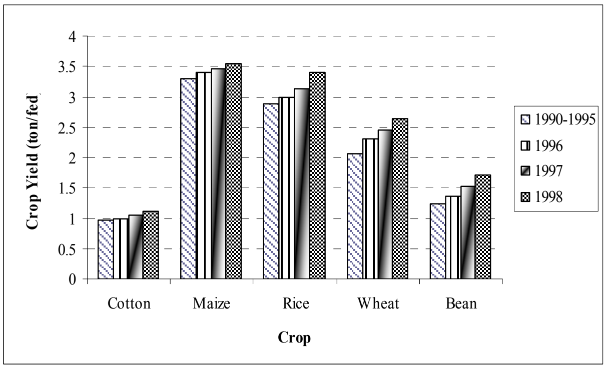

Fig. 1 The average yields pre and post the subsurface drainage system.

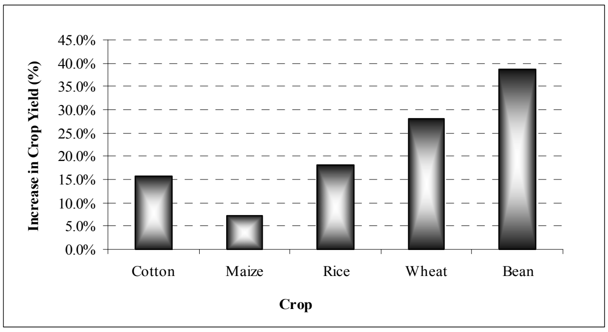

Fig. 2 The post subsurface drainage system percentage increases in the yields of crops.

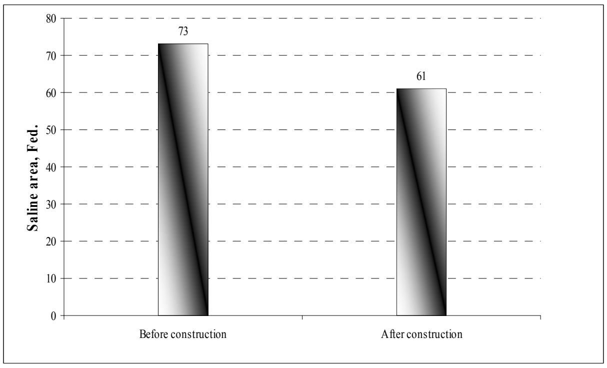

Fig. 3 The saline areas before and after the subsurface drainage system.

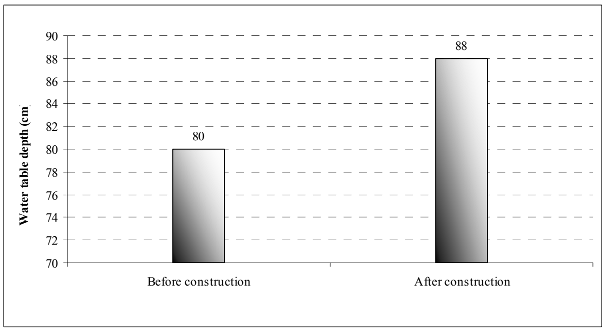

Fig. 4 The water table depths before and after the subsurface drainage system.

are graphically represented in Fig. 1. There is a significant increase in the yields. The post subsurface drainage system percentage increases in the yields of cotton, maize, rice, wheat, and bean are 15.6%, 7.3%, 18.1%, 28.2% and 38.7%, respectively, as illustrated in Fig. 2.

For the second environmental impact concerning salinity, soils with an EC (electric conductivity) greater than 4 dS/m are considered saline. Actually, salt-sensitive plants may be affected by electric conductivities less than 4 dS/m. Thus, for land reclamation, salinity should be defined in terms of the pre-disturbance land use potential, the proposed post-disturbance land use, and the plant species to be seeded on the site [6].

However, the saline areas in Ibshan were 73 feddans before the subsurface drainage system. These areas are reduced to 61 feddans after the subsurface drainage system, as illustrated in Fig. 3. The percentage of improved areas is 16.4%. This reduction in saline areas means increasing cultivated lands that give more crops yields for people and the country as a whole.

For the third environmental impact concerning the water table depth, observation points are selected all over the area of the subsurface drainage system in Ibshan as mentioned before. The water table depth is measured from the ground surface to the water table.

The average water depths before and after the subsurface drainage system are 80 cm and 88 cm respectively, as shown in Fig. 4. This reduction in water table depth due to the subsurface drainage system in Ibshan area is 10%.

The ground water table management simulation model, DRAINMOD-S, is employed to evaluate the water table depth with different subsurface drainage spacing [4].

As shown in Fig. 5, there are two basic equations of DRAINMOD-S for water balances for a time increment, Δt = 1h.

The first equation concerns the water balance for a thin section of soil of unit surface area that extends

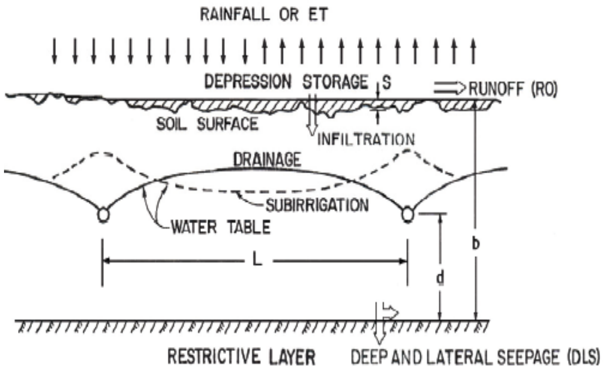

Fig. 5 Principal hydrologic components of a subsurface drainage and water table management system [4].

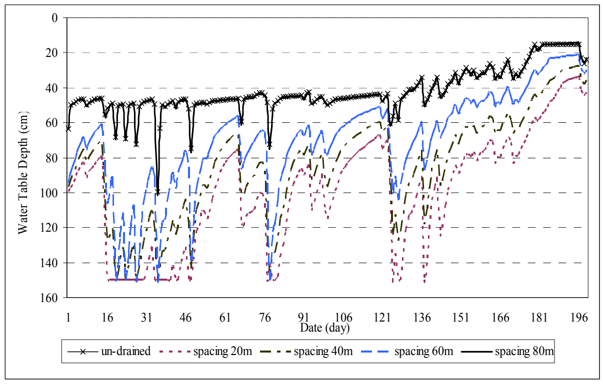

Fig. 6 Water table depth for different subsurface laterals spacing.

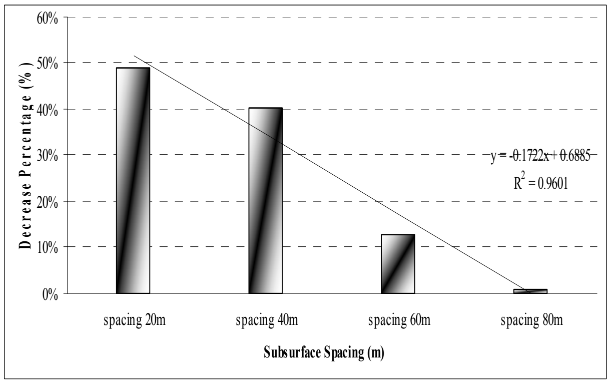

Fig. 7 The relation between the percentage decrease of ground water table depth and the subsurface laterals spacing.

from the impermeable layer to the surface and is located midway between adjacent drains.

$$\Delta va = D + ET + DS - F \quad (1)$$

where,

Δva : change in air volume (cm);

D: lateral drainage (cm);

ET: evapotranspiration (cm);

DS: deep seepage (cm);

F: infiltration (cm).

While the second equation concerns the water balance at soil surface.

$$P = F + \Delta S + Ro \quad (2)$$

where,

P: precipitation (cm);

F: infiltration (cm);

ΔS: change in volume of water stored on surface (cm);

Ro: runoff (cm).

In this paper, the DRAINMOD-S program is employed for five cases. The first case assumes no subsurface drainage system. The other four cases are set for the subsurface drainage system with spacing between laterals of 20 m, 40 m, 60 m and 80 m. The laterals level is at 150 cm from the ground surface. The program is carried out for a year. Fig. 6 shows the water table depths for different subsurface laterals spacing.

The lowest ground water table depths are got for laterals spacing of 20 m. While at the laterals spacing of 80 m, there is almost no effect on the ground water table depths.

The decreases of ground water table depths are considered as percentage ratios, and are illustrated in Fig. 7. It is obvious that the subsurface laterals spacing of 20 m is associated with the most decrease of about 49%. While the subsurface laterals spacing of 80 m is associated with the lowest decrease of about only 1%. The water table depth is reduced by about 10% when the subsurface laterals spacing is changed from 20 m to 40 m.

For the relation between the percentage decrease of ground water table depth and the subsurface laterals spacing, a linear regression analysis is adapted employing micro soft excel software, as shown also in Fig. 7.

The obtained equation is:

$$D = -0.1722\, S + 0.6885 \quad (3)$$

where,

D: the decrease of ground water table depth (%);

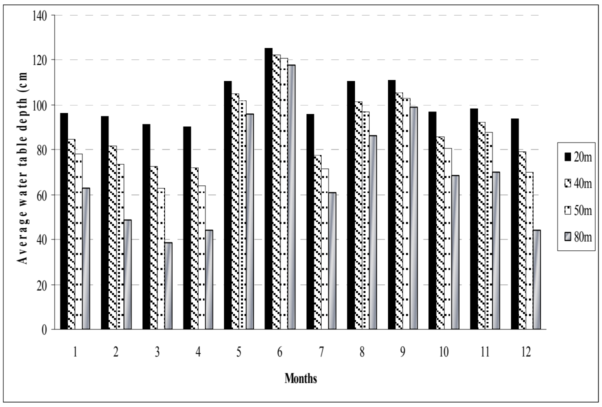

Fig. 8 The average water table depths in different months for different laterals spacing.

S: the laterals spacing of the subsurface drainage system (m).

For different laterals spacing, the average water table depths in different months are shown in Fig. 8.

4. Conclusions and Recommendations

It is concluded that the environmental impacts of the subsurface drainage system in Ibshan area are very good. The yields of five crops increased from 7% to 38%, 16.4% of saline areas are improved, and the ground water table depth is reduced by 10%.

An equation is obtained to predict the percentage decrease of ground water table depth according to the laterals spacing of the subsurface drainage system.

It is recommended to apply the obtained equation to other different areas, and compare its results with the records of pre and post subsurface drainage systems.

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Distribution of Polycyclic Aromatic Hydrocarbons in Marsh, Plants and Sediments in Iraq

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Abstract: This work represents sources of polycyclic aromatic hydrocarbons in the local environment of five major stations at marshland in southern Iraq from May 2013. Average concentration of PAHs (polycyclic aromatic hydrocarbons) in the sampling sediments and three types of plants were lower than the guideline value. This study examined presence of PAHs may from reach aquatic environment in marshes, deposition of airborne particles. Having a relatively low water solubility to the suspended particulate matter, most of the PAHs introduced to the aquatic environment tend to accumulate in bottom sediments. Sedimentary PAHs may thus provide a record of the input and history of these pollutants, and the distribution of PAH\'s in aquatic sediments has received considerable attention. Owing to the concentration of PAHs in the study area, its concentration level still meets the sediment quality guideline value (ERL: 4,022 ng/g dry weight); however, according to the PELq (probable effects level) factor, slightly adverse biological effects are associated with the exposure to PAHs levels in the study area ($0.1 < PELq = 0.24 < 0.5$).

Key words: Iraqi marsh, pollution, PAHs (polycyclic aromatic hydrocarbons), sediments.

1. Introduction

The portions of marshes environments these areas cannot be isolated from the effects of different environmental variables, and sediments may act as a temporary or long-term reservoir of contaminants accompanied by natural origin compounds. Aliphatic and polycyclic aromatic hydrocarbon compounds are omnipresent components of marshes sediments and derive from natural and anthropogenic sources. The natural concentration of chemical compounds is characterized as a base and background for identifying the portion of anthropogenic sources [1, 2].

PAHs (polycyclic aromatic hydrocarbons) originate mainly from incomplete combustion of organic materials as well as petroleum. Due to their hydrophobic nature, PAHs in the aquatic environment rapidly bind with particles and deposited sediments become their primary reservoirs [3]. The occurrence of PAHs in soils, sediments, aerosols, waters, animals and plants is of increasing environmental concern because some PAHs may exhibit mutagenic [4] the levels of PAHs commonly found in many aquatic environments which are an important risk factor for various health aspects [5]. PAHs represent a major problem to urban environments since they are among the most toxic compounds [6]. Because of their low aqueous solubility PAHs adsorb to particulate material and are deposited in sediments, where they can accumulate in higher concentrations. They tend to accumulate in biota [4].

Marshes provide a unique opportunity to assess the chronic input of land-derived pollutants to aquatic ecosystems. Contaminants that accumulate on land and are eroded by rain result in runoff that carries the chemical signature of the land it traverses. Since residential and undeveloped land uses are associated with different levels of PAH accumulation, adjacent

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wetland sediment should reflect the differences in PAH concentration as they scavenge particles from runoff [7, 8], PAH compounds have been listed as priority pollutants by the USEPA (United States Environmental Protection Agency) and the European Union. Increasing attention has been paid to the environmental behavior of PAHs on a global scale due to their long-range transport potentials. Because the global oceans are likely a gigantic sink for organic contaminants derived from a variety of source [9].

1.1 Aim of Study

The study goals (1) measure PAH concentrations in marshes of sediments and some dominant plants; (2) assess whether the PAH concentrations observed were at levels of biological through using representative estuarine species that inhabit these areas to study the spatial and vertical distribution of PAHs in the sediment of the Marshes and to evaluate the importance of potential sources and routes by which PAHs reach the wetland.

2. Materials and Methods

2.1 Site Description

The study areas are points along the major marshes (Hawizeh, Hammer and The Central Marsh) in southeast Iraq. Hawizeh marsh is located to the east of the Tigris River in Misan Governorate. Depending on the time of the season, Hawizeh marsh could cover about 3,000 km^2. Al-Hammar Marsh is situated almost entirely south of the Euphrates, extending from near Al-Nasiriyah in the west to the outskirts of Basrah on Shatt al-Arab in the east. Al-Hammar marshes are bordered by a sand dune belt of the Southern Desert and which dominates the marshes, is the largest water body in the lower Euphrates. It is approximately 120 km long and 25 km at its widest point. Maximum depth at low water levels is 1.8 m.

2.2 Sample Collection and Preparation

The plant species were identified as *Ceratophyllum demersum*, *Typha domengensis* and *Phragmites australis*. They are the most common plant species in the sampled locations. The plants were collected from study marshes in cleaned polyethylene bags. In the lab, the plant samples were grinded and oven dried. They were then sieved and prepared for analysis. All samples were transferred to the laboratory immediately. The analysis of PAHs was conducted according to standard method procedures [8]. All extracts were dried using anhydrous sodium sulfate and concentrated by a rotary evaporator.

Pure PAHs: naphthalene, phenanthrene, chrysene, benzo[a]anthracene and benzo[a]-pyrene (> 99%, Aldrich). The concentrated extracts were diluted by adding 10 mL hexane and then concentrated to 2 mL. Freshly prepared copper granules were added to the extracts for sulfur removal [10]. The removal of co-extracted contaminants from PAHs was achieved by florisil adsorption in which concentrated extracts were added to hexane pre-washed activated micro-florisil columns [11]. The columns were rinsed with at least 15 mL dichloromethane and hexane mixture (2:8) and the collected extracts concentrated to 1 mL. The extracts were finally made up to 2 mL with hexane in a volumetric flask and 10 mL of internal standard was added for gas chromatographic analysis.

A GC-MS system consisted of an Agilent 6,890 gas chromatography with a GC column (DB-5 ms 30 m long, 0.25 mm internal diameter, 0.25 mm coating) and an Agilent 5,973 mass spectrometer was used for PAH determination. SIM (selected ion monitoring) mode was employed for identification and quantification of 15 individual PAH compounds, which have been identified as priority pollutants by the USEPA (United States Environmental Protection Agency) due to their toxic, mutagenic and carcinogenic characteristics [12, 13].

2.3 PAH Analysis

Approximately 8 g of wet sediment was Soxhlet

extracted for 48 h in 50/50 dichloromethane (DCM)/acetone (v/v). A surrogate standard composed of deuterated naphthalene, anthracene, benzo(a)anthracene, benzo(a)-pyrene and benzo(ghi)perylene was added before extraction.

PAHs were eluted from the silica by adding 25 mL hexane followed by 50 mL of 20% DCM in hexane (v:v). The PAH fraction (20% DCM in hexane) was concentrated to 1 mL by rotary evaporation and an internal standard comprised of deuterated acenaphthene, phenanthrene, chrysene and perylene was then added. PAHs were quantified using a GC (gas chromatograph) and an electron impact MS (mass spectrometer) operated in the SIM (selective ion monitoring) mode. All surrogate standards had recoveries greater than 70%. Samples were not corrected for recoveries. Procedural blanks were run with every batch of extractions. Batches of samples were not used if associated procedural blank had quantifiable PAHs.

A total of 16 PAH compounds were resolved, three of which were methylated. All sample concentrations were calculated using standardized relative response factors run with each batch. Each sample was analyzed by gas chromatography mass spectrometry (GC-MS; GC, Agilent, 6890N, MS: Agilent, 5973N) for PAHs [13, 14]. Finally, the concentration of the following PAHs was determined: Naphthalene (Na), Acenaphthylene (Acpy), Acenaphthene (Acp), Fluorene (Flur), Phenanthrene (Phen) and Anthracene (Ant), Fluoranthene (Flu), Pyrene (Py), Benzo(a)anthracene (BaA), Chrysene (Chr), Benzo(b)fluoranthene (BbF), Benzo(k) fluoranthene (BkF), Benzo(a)pyrene (BaP), Dibenzo(a, h)anthracene (DbahA), Benzo (g, h, i) perylene (BghiP), Indeno(1, 2, 3-cd)pyrene (IP).

Data analyses were performed using Sigma plot Statistics version 12.5 by using one-way ANOVA to test to compare the concentrations of aromatic hydrocarbons in sediments and some plant of different stations was used. If there were significant differences between the stations, the Sigma Plot test was used to determine which stations differed significantly. All steps were carried out in SPSS Version 12.5, and each of the graphs was plotted in Excel software.

3. Results

3.1 Distribution of PAHs in the SQGs (Sediments Quality Guidelines)

SQGs were used to assess adverse biological effect in this area [15-17]. This SQGs method indicates that the relationship between the concentrations of contaminants in sediment samples and adverse biological effects is based on the specific values of effect range low or TEL (threshold effect level) and effect range medium or PEL (probable effects level). The TEL value has been estimated as the concentration of contaminants with a relatively low effect on biological communities, and PEL is a concentration of contaminants with high toxic effects.

Occasional toxic effects are expected to occur from contaminates concentrations between TEL and PEL occasional toxic effect are expected [18-21].

The PELq factor is the average of the ratios between the concentration of these parameters the sediment sample and the related PEL value [22-24]. This factor describes contamination effect on biological organisms in sediment which range as non-adverse effect (PELq < 0.1), slightly adverse effect ($0.1 <$ PELq < 0.5), moderately adverse effect ($0.5 <$ PELq < 1.5) and heavily adverse effect (PELq > 1.5) [20].

Ecological risk assessment based on the sediment quality guidelines showed that, most of the stations can be categorized as non-adverse effects (PELq < 0.1) except stations, 3-BI, 4-BI and 5-R which are categorized as slightly adverse effects ($0.1 <$ PELq < 0.5), and the station 4 which is classified as heavily adverse effects (PELq > 1.5). The relatively low flow allows pollutants to enter the sediments. Accordingly, the high levels of these compounds PAHs at this station are probably due to amount of water entering marshes.

For comparison between previous studies observed the difference in the values depends on the nature of the sources of the contaminated area. Levels of PAHs

in the order of 1.6 µg/g dw (dry weight) range 1.2-5.3 µg/g, depending upon the fraction of domestic waste in the treatment marshes. Little current data are available on the concentrations of PAHs.

Table 1 shows PAHs concentration in sediments and Table 2 shows comparison of total PAH concentrations in surface sediments for various estuarine and wetland sites determined the levels of PAH contamination in sediments and classified the range of concentrations of these compounds as follows: 0-100 ng/g dry weight concentrations as low levels of contamination, concentration 100-1,000 ng/g dry weight as the average level of contamination, concentrations 1,000-5,000 ng/g dry weight as the high level of pollution and concentrations > 5,000 ng/g dry weight, as very high levels of contamination.

3.2 Distribution of PAHs in the Plants

Since all of the plants belonging to any class Macrophyta not be committed its roots are the marsh soil so the ratio of absorption of low of it that is emitted muds sediments in the waters of marsh. The possible toxic chemicals include PAHs, cyanides, phenols, volatile compounds and heavy metals. Nonetheless, all locations showed a well-flourishing [11-13, 24, 25] vegetation, some-what enhanced by fertilisers at the decontamination Ecological assessment of PAHs compounds and the average concentration of PAHs in the plant, *Ceratophyllum demersum*, *Typha domengensis* and *Phragmites australis,* respectively, depending on the tissue the plant and its ability to absorb these components which apparently do not impede plant in this study highlighted via two main problems, first of all, the scarcity of information on the PAHs concentrations in the sediments, and no background was available. The second problem was related to the biological effects and guidelines as were unavailable to marshes. Owing to the concentration of PAHs in the study area, its concentration level was still meet the NOAA sediment quality guideline value (ERL = 4,022 ng/g dry weight); however, according to the PELq factor, the study area can be categorized as slightly ecological adverse effect (0.1 < PELq = 0.24 < 0.5). It may lead to these organic compounds finding their way into the food chain. Because the study was located in heavily industrialized and polluted regions of central south Iraq, there is a very high possibility that locals will be exposed to some levels of PAHs in water and other environmental media. Can show the PAHs concentration averege in three type plant in marshes in Fig. 1.

Table 1 PAHs concentration in sediments.

Concentration low total	Station 1	Station 2	Station 3	Station 4	Station 5
Σ PAHs	6.37	5.1	6.01	6.33	5.27
PELq	0.5	0.4	0.4	0.16	0.29

Sediments selected PAH composition lg/g dry wt;
PEL: probable effects level.

Table 2 Comparison of total PAH concentrations in surface sediments for various estuarine and wetland sites.

Site	Low total PAH concentration	High total PAH concentration
Iraq marsh a	0.59	2.07
South Carolina marsh b	0.069	37
Elizabeth River surface sedimentsc	1.4	172
Baltimore Harbord	0.089	30
Iraq Marshe in this data	1.3	4.65

Concentrations in (ug/g dry sediment).
A: Al-Saad and Al-Timari (1989); b: Sanger et al. (1999); c: Huggett et al. (1988); d: Ashley and Baker (1999).

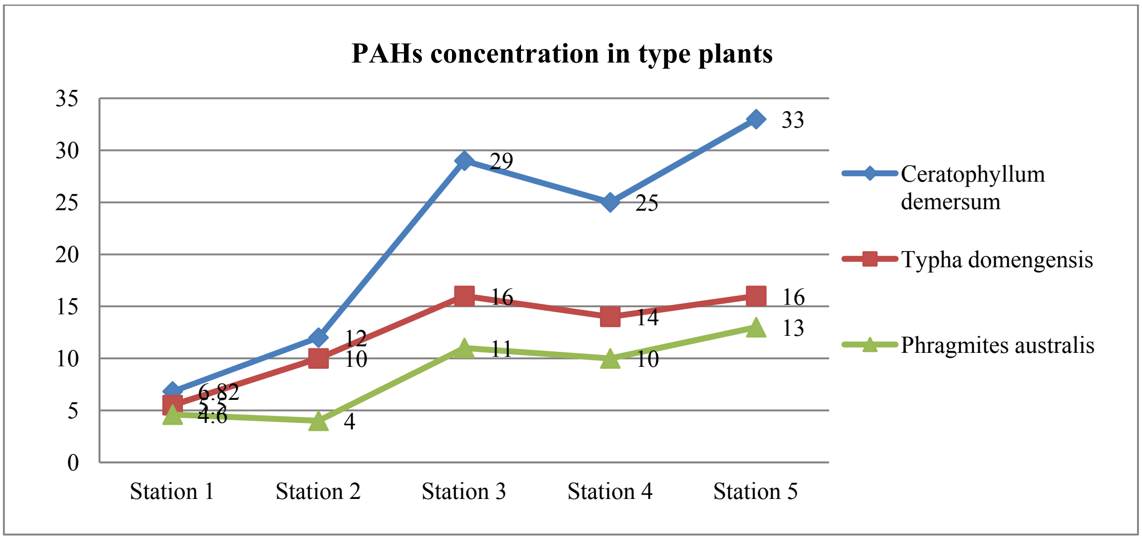

Fig. 1 PAHs high contamination average in three type plant in marshes.

4. Conclusion

The present work represents sources of polycyclic aromatic hydrocarbons in the local environment of the marshes in southern Iraq average concentration of PAHs in the sampling sediments and plants of the marshes were lower than the guideline value. Thus, according to the above discussion, it may be concluded that PAHs are not the main pollutants of potential concern in the study area. Also, in the present study highlighted that slightly adverse biological effects are associated with the exposure to PAHs levels probably due to the dynamic hydrological conditions of the wetland. On the other hand, the high PAH content in the surface 0 cm to 6 cm. High PAHs do not inhibit plant germination and growth, water-soluble substances such as benzene, toluene, xylenes (BTX), styrene, indene, naphthalene and other possible toxic molecules. Since these small aromatic compounds are water soluble and biodegradable, their removal from contaminated water and sediments, e.g., by weathering, tillage and fertilisation, should allow the growth of plants. Further work is in progress to test the ability of plants to improve PAHs. Differences were observed between stations. In the near future, higher concentrations of Al may be observed in this area due to increase the different discharge.

Acknowledgement

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Goal-Setting in the Information-Generating Environment of the Universe

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Abstract: Problem of goal-setting is related to the fundamental principles of informationology and general, rather than specific, aproaches, which enable a more adequate appraisal of certain managerial decisions in terms of their efficiency. In article this problem is considered and from positions of informationology is formulated and on the basis of a method of full mathematical induction the Law of positive dynamics of the Universe is proved. This law establishes preference of the positive purposes in all processes happening in the Universe. Thus, the goal-setting which is carried out from positions of the described Law is the important world outlook prerequisite searching, identification and development of strategic alternatives of purposeful social innovations.

Key words: Goal-setting, informationology, law of positive dynamics of the Universe.

1. Introduction

Secular science and religion have been vehemently confronting each other for centuries: science fundamentalists would claim that all the clergys are obscurants whereas the church retorted by calling scientists "limb of the devil".

This situation changed dramatically with the introduction of a new scientific field known as "informationology". The foundation for this area of research was laid by our fellow-countryman Professor Yuzvishin, whose book "Informationology" was first published in 1992.

Contrary to the materialistic (and atheistic) notion according to which matter is primary, Yuzvishin maintains: "The Universe is saturated with information; information is primary and matter is secondary. It is not that being defines conscience but information (conscience) defines being. Information comprises all the sources of primary causes for the phenomena which occur in the Universe at both micro- and macro levels" [1]. For the first time in the history of science an information model of the Universe has been proposed, which provides a real opening for a constructive dialog between scientific and religious worldviews. Yuzvishin observes: "Ancient thinkers, clergymen and scientists saw the same essence of the Universe from various sides-they saw its endless information processes, i.e., information, or, from the standpoint of religion, God" [1]. In other words, in present conditions, both religion and science, while approaching truth from different directions (and with different methodological tools), enable a more complete comprehension of the Universe and all the processes which take place in it.

For almost 10 years now, Volga-Vyatka Academy of Civil Service has been the venue for International Symposium "Dialog of Worldviews"; this event features representatives of various religious confessions common in the region of Nizhny Novgorod, scientists and government officials. Below is a short list of issues discussed at the Symposium:

- Human nature from the standpoint of science and

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religion;

• Social aspect of an individual; an individual and the society;

• Human nature and nature of the society; development of a person and development of the society;

• Types of society and human nature;

• Religion and personal type;

• Is an individual a "social atom";

• Solidarity, dialog and struggle of individuals as various sides of social life;

• Human nature and possible dialog of science and religion;

• Human nature and possible dialog of cultures and civilizations.

Based on the fundamental principles of informationology and in accordance with Yuzvishin's foresight, scientific community has put forward some new information laws which advance this new area of research.

2. Materials and Methods

In the complex modern world, which is changing ever faster, it is extremely important to set the right objectives, because clearly set objectives are a prerequisite of successful social transformations. Generally speaking, this problem is related to the fundamental principles of informationology and general, rather than specific, approaches, which enable a more adequate appraisal of certain managerial decisions in terms of their efficiency.

As far as animated nature is concerned, its every element develops in order to survive, to exist and to reproduce. Charles Darwin was first to argue this point in his theory of natural selection. Karl Marx adapted this idea to the development of human society and he came up with the theory of class struggle. And today the notion that struggle is a source of any development and any change remains dominant. Usually, when it comes to discussing natural selection and struggle for survival, people focus on the influence of natural environment, whose changes make the system respond. However, metasystemacity, multiply connected and complex character of the modern world forces researches to significantly amend Marx's theory. The society is characterized, among other features, by the fact that the social system adapts not only to the spontaneously changing environment, which is, moreover, not the main factor (these situations are relatively common), but to its own growing capabilities and results of human activity, as the social stability is quite often disrupted by the society itself (it is enough to mention the Chernobyl disaster).

Supporters of the synergetic approach point out that in social systems selection in the traditional sense of the word acts only as a trigger for processes of self-organization (i.e., structuring of the system) [2, 3]. In this approach one can point to significant differences of synergetic selection (transformation) from the Darwin's theory of biological selection. These differences are following:

(1) In social systems the choice is not made from the multitude of objects in the event-driven physical environment but in the environment of information images (possible structures, projects, anticipated states);

(2) Social systems make their choices not only through competition but through co-operation as well;

(3) In social selection of development alternatives, there is an act of decision-making usually implemented by a special selector—an organizational structure responsible for achieving the maximum stability in the system.

Humans are set apart from animals by their ability to set objectives: human actions are not based on natural instincts, and they are based on setting new objectives and on working out ways to achieve them.

So it is impossible to explain the internal logic of social development (its essence and its purpose) solely by the drive to the maximal stability expressed in survival and reproduction. To understand this logic by employing the concept of information-entropic

properties of objects with complex organization, it should be noted that for the human society not only the amount of structural information, which preserves the integrity of social structure, is of vital importance, but also the essence and the value of this information. In other words, information which circulates in socio-economic systems has a distinct social character, and it is this aspect of information that has a direct link to the setting of objectives in social organizational structures.

This social information is used for achieving objectives of vital importance for the human society as a complex social system and for every individual as an element of this system.

An approximate list of such objectives can be drawn as follows:

(1) Supporting one's own existence and one's reproduction. As far as an individual is concerned, it means earning a living, taking care of one's health, having children. For an organizational structure it primarily involves achieving economic results (profit, cost efficiency, etc.) which guarantee survival on the market.

(2) Satisfaction of social needs. For individuals these objectives involve the ambition to be accepted in certain communities (both formal and informal) as a manifestation of this individual's social adaptation. For organizational structures this type of objectives reflects their desire to meet social expectations: satisfying consumer demand—for commercial entities, meeting voters' expectations—for governing bodies.

It can be observed that for certain elected officials, objectives of this type coincide with the objective to prolong their existence in the given office. The difference in the objectives of the first and second type depends upon the social responsibility of those officials. The concept of social responsibility [4] also concerns commercial entities, and it is of great importance in setting the objectives.

(3) Satisfaction of spiritual needs. For an individual those include getting an education, choosing leisure-time activities, socializing, learning the world, shaping one's own personality when a socialized individual displays in a social environment their very own characteristics (aptitudes, capabilities, talents). For an organization those include processes which shape organizational culture in accordance with existing social values and in order to facilitate the fulfillment of each employee's potential and their unhindered development.

In terms of goals, the principle of social system functioning is sometimes defined as follows: a developing social organism strives to achieve some kind of ideal, and to do so it sets itself certain objectives. As the environment experiences constant changes, stability or quiescence can not be the ideal of an open social system. As paradoxical as it sounds, a system is the most resistant to external forces when it is the most unstable. Prigozhin [5] maintaind that the ideal to which any social structure should aspire can be described as "not being but shaping up". In other words, it should not be being as an externally observed stability but formation process (non-equilibrium) as the fundamental condition of existence.

However, the way to the ideal is not straightforward and unambiguously determined; since multiple factors impact the system, the ideal itself becomes fluid and "unstable" but it always exists. It acts as a cause for the structuring of complex objects and, in the final analysis, as a cause of crises and chaos. This "paradox" is a manifestation of the objective law of development of all things alive: order through chaos, organization through disorganization, life through death.

This substantially modifies the notion of progress. It can now be viewed not as a movement from simple to complicated, as it is presumed in the linear dynamics of development, but, in the first place, as an approach to that ideal state, a "blueprint" of which certain social system drew at some point of its development.

Therefore, the goal of development for any

organizational structure is not some “most attractive point” but movement itself, the way, which fully corresponds to the Latin saying: “Via est vita”, which means “Life is a way”. However, the issue of the direction of this movement in Prigozhin’s works was left unresolved, since any road permits movement in two opposing directions. This eternal problem was reflected in old Russian fables where there was a rock at the crossroads with the inscriptions: “If you go left… If you go right…” It is necessary to find the answer to this fundamental question.

3. Results and Discussion

Despite the great variety of problems with which we are faced, all of them can be generally narrowed down to two types: the first one is to do with the removal or confinement of something undesirable that exist; the other one is pertinent to the achievement or acquisition of something that is desirable but does not exists. Finding a solution to problems of the first type means removing the source of present discontent (e.g., illness, distracting noise); objectives of this type can be described as negative. Finding a solution to problems of the second type means gaining access to the source of satisfaction (e.g., meeting a friend, obtaining a needed book, etc.); objectives of this type can be described as negative.

It is important to point out that a positive objective may entail the achievement of a negative objective whereas the opposite statement is not true. In most cases getting rid of something undesirable is not equivalent to obtaining something desirable. Thus, getting rid of toothache by taking a pill or undergoing a dental procedure will not guarantee an impeccable health. At the same time, when impeccable health is set as an objective, toothache is overcome automatically. This is something that an executive should take into account when dealing with various conflicts within their organization. Such conflicts, as a rule, result from the dissatisfaction with the current state of affairs and with the desire to overcome it (bad boss, unbearable colleague, etc.). When efforts are dedicated to the achievement of a negative objective, it is tantamount to taking a way of struggle, to aggravating a conflict and, in the final analysis, it is destructive. At the same time, the problem can be redefined in terms of positive objectives, such as expansion of the organization. That will lead to the hiring of new employees, to the improved skills of the staff, and that will inevitably resolve the conflict, since the expanded operation will require true professionals and baseless complaints will disappear. It should be noted that redefining the problem in such a way may not be easy. And it always requires reaching to a higher level of the system within the framework of which automatic achievement of a negative objective is possible. That means that an automatic solution to a problem defined as negative can only be found in a system whose rank is superior to the one in which that negative objective was set.

It is necessary to notice that more often than not the objective is set to remove something that is undesirable. When efforts are dedicated to overcoming the undesirable (negative objectives), it is a retrospective, past-oriented type of problem-solving. Applying efforts to the achievement of something that is necessary but at the moment unavailable (positive objectives) corresponds to the forward-looking, future-oriented problem-solving. With this approach we select the frontiers which ought to be reached and we try to reach them. In this case some important consequences of our decisions may be overlooked but it is not very likely. The hastier we are in our attempts to rid ourselves from the source of our dissatisfaction, the more likely we will overlook some important consequences. There is no shortage of negative examples with this approach. We can recall the mass extermination of sparrows in China which was prompted by the harm those birds did to the crops. Achieving that negative objective resulted in unhindered propagation of insect pests, on which sparrows fed, and, consequently, to catastrophic losses

in agriculture. Therefore, the risk to overlook important consequences is minimized when the problem is formulated in terms of approaching one or several ideals.

When the attention is concentrated on the negative aspects of the existing state of affairs (negative objectives), we inevitably consider these negative aspects independently of one another. With this approach many of those negatives are hard to overcome. On the other hand, when we aspire to some ideal (positive objectives), we can identify some connections between various future events which makes us consider a multitude of interconnected risks and opportunities as one whole, as a system of problems.

A system as a whole always possesses some properties which are absent in its separate elements. For example, an individual can read, write, run and so on, but neither a single part of their body nor any unconnected assembly of such parts can do that on their own. Hence, a system of solutions for interconnected problems always possesses properties which its separate parts lack. On the other hand, those parts, when assembled into a system, acquire properties which they previously did not have.

So, as the above-mentioned examples have clearly indicated, positive objectives are preferable, and this is a general rule. And if you assume that this rule applies to all the objects, it will lead you to the conclusion that there is no equilibrium (in the traditional sense) between the "positive" and the "negative", yin and yang, and, if you continue this list, between "good" and "evil". Therefore, the Universe does not possess symmetry but rather it has a vector of "preferable" development which follows from the fact that positive objectives are preferable and they have more in common.

Let us prove it by formulating the Law of positive dynamics of the Universe[1].

[1] This Law suggested and proven by the author was registered by the International Registration Chamber of informational and intellectual novelty (Certificate # 000379, Mar. 24, 1999)

4. The Law of Positive Dynamics of the Universe

The Universe is a purposeful metasystem which has a vector of development pointing towards achievement of positive objectives; of all possible alternative processes taking place in the Universe, only the processes aimed at achieving positive objectives reduce the entropy of the Universe.

To prove this law we will employ the method of complete induction.

(1) In a number of instances, when problems, formulated in terms of positive and negative objectives, were to be solved, it was established that a positive objective entails achieving a negative objective as well, however, the reverse statement is not true. The implementation of this positive objective property in each case of problem-solving with a new formulation of the objective as positive, requires transition to a system of a higher rank, in which a more general problem is to be considered. Achieving this positive objective will automatically lead to the achievement of the previously formulated negative objective. From this it follows that:

$$M(X_1) \in M(X_2) \quad (1)$$

$M(X_1)$ in Eq. (1) signifies a set, which contains all the solutions X_1 of the problem, formulated in the first system (subscript 1 for the variable X_1) as negative. When moving to a higher rank of the system (subscript 1 for the variable X_2), the objective is redefined as positive. Eq. (1) suggests that the multitude of solutions contained in the rank 1 system is found in its entirety in the multitude of solutions for the rank 2 system. I.e., if a solution is found for the problem in the higher-ranked system 2, then a solution is found for the problem in the system 1, where a negative objective was formulated.

(2) At a higher level, in a rank 2 system, new problems may emerge for which negative objectives are formulated. Then a transition to a higher ranked system 3 will be required where a positive objective (objectives) will be formulated with a solution vector

X_3. For this situation Eq. (2) can be drawn and it has the same meaning as Eq. (1)

$$M(X_2) \in M(X_3) \quad (2)$$

Therefore, when problems, formulated in terms of negative objectives, emerge, one can always find a system of a higher rank for which a positive objective can be formulated; in this system, the multitude of its solutions include the multitude of solutions of the lower-ranked system with a negative objective.

(3) In accordance with the induction method, let us assume that the established relationship is true for any sequence member:

$$M(X_{k-1}) \in M(X_k) \quad (3)$$

(4) The complete induction method requires that in the assumption Eq. (3) this relationship must be proven true in regard to the next (k+1) sequence member, that is

$$M(X_k) \in M(X_{k+1}) \quad (4)$$

Proof. Let us assume that condition Eq. (4) is not met, hence $M(X_k) \notin M(X_{k+1})$. That means that at a certain step of problem-solving (step number k) a higher-ranked system for the formulation of positive objective can not be found. Such an assumption can only be true for limited complex systems, whose highest rank is defined by the given problem. However, this assumption can not be true in regard to the Universe because the latter is infinite. The infinite nature of the Universe is indisputable, and from this follows the fact that for any system or complex system, regardless of their rank, another system with a superior rank can always be found.

Therefore, the assumption $M(X_k) \in M(X_{k+1})$ can not be true. Thus, we can consider Eq. (4) to be proven, and with it proven is the postulate on the purposeful nature of the Universe which is driven toward positive objectives.

This brings us to the proof of the second postulate of the law under consideration. As long as entropy in the developing Universe is maintained at the level which supports its existence, then, in accordance with the proven law, compensation of losses (that is, reduction of entropy), by virtue of the purposeful nature of the Universe, can only be achieved with the processes driven towards positive objectives.

When considering the ranking of systems one can realize that for a system of inferior rank, setting the objectives takes place in a system of a higher rank (environment, circumstances). Since the purposeful Universe is infinite and it is the highest ranked system, a natural question arises: who (or what) formulates the purpose of the Universe? When answering this question we inevitably come to admit the existence of Higher Reason (Logos, Lord, God, Providence, Information, Noosphere) whose will formulate this purpose. The multitude of terms comes from the fact that we have entered the system of the highest rank where we reach incomprehensibility level.

This Higher Reason is an extra-systemic substance which crosses the "limits" of limitless Universe, and, in this sense, it is unknowable. Now it can be seen that the proven Law on the purposeful nature of the Universe is, at the same time, a scientific proof of the existence of the Higher Reason.

Based on the above Law, three important practical conclusions can be drawn.

(1) The fact that any system is purpose-driven alongside the positive objectives vector guarantees final success in problem-solving when positive objectives are set, since only in this case efforts of the implementer (executive, business person, etc.) coincide with the purpose of Providence. Traditional wisdom describes these situations with a saying: "Lord himself assists him". When the implementer sets negative objectives, he (she) is faced with resistance of Providence, since their efforts (both physical or organizational and mental or informational) are directed against the vector of Universe's positive dynamics.

(2) When negative objectives are formally "reset" to become positive, without ascending to a higher-ranked system, it can not guarantee automatic achievement of negative objectives. To achieve those

objectives one must ascend to a system of a higher rank. Such a transition represents a forward-looking type of problem-solving as opposed to a retrospective type, which is based on past information. However, such a transition does not automatically lead to an easy solution: as a rule, this transition requires large resources, including time.

(3) When an implementer in search of a solution cannot formulate a positive objective, it means that, above all, he (she) has failed to find the required system of a higher rank which would include the multitude of solutions to the problem in the existing system. As long as such a higher-ranked system always exists (see the Law above), a new formulation of the problem, which enables entering such a system, must be sought.

It should be noted that the above Law of positive dynamics of the Universe is in full agreement with Prigozhin's works which show the absence of symmetry in open systems development processes, that is, those systems possess a "preferable" development vector.

5. Conclusions

Therefore, it can be concluded that errors in the setting of strategic goals (including the goals defined for social reforms) can ruin all efforts aimed at structural transformations. All the actions could appear to be "right" but the result of implemented reforms might fall short of the expectations or even prove negative. As we already said, this happens when efforts are committed to the achievement of negative objectives, i.e., when they are directed at the overcoming or removing of something that stands in the way.

There is no shortage of examples which corroborate these conclusions. And the reader can probably recall situations in which, despite all the efforts, the desired result was not achieved or even some harm was done in the process. One can be certain that in all those instances the drive was toward the achievement of negative objectives and a way to reformulate problems in terms of positive objectives was not found.

Whereas a positive objectives vector can almost always be found by an organization or individual, the problem of finding the Universe's positive dynamics vector is yet to be solved. Since the goal at this level is set by an extra-systemic unknowable substance (according to the Law of Universe's positive dynamics), which crosses the "limits" of the limitless Universe, the direction of the vector of "absolutely" positive objectives is, strictly speaking, also unknowable (which resonates with the saying "God works in mysterious ways"). But it does not mean that a person is completely helpless when searching for positive objectives corresponding to such an "absolute". The system of values developed by the humankind can serve as a conceptual basis for the objective-setting process. And as a starting point for those values (as, for instance, in the Orthodox Christianity) the Ten Commandments of the Bible can be chosen.

Therefore, the choice of objectives made on the basis of the Law described above represents an important paradigm for identification and development of strategic alternatives for purposeful social innovations.

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Effect of Different Winter Cover Crops on Carbon Dioxide Emission in Paddy Field of Double Cropping Rice Area in Southern China

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Abstract: In this study, a two-year experiment was conducted by suing a static chamber method to observe the effects of straw recycling of winter cover crops measure on CO_2 emission fluxes in southern China. Three patterns of winter use were performed in the paddy field, including RRR (rice-rice-ryegrass (*Lolium multiflorum* L.) cropping system), CRR (rice-rice-Chinese milk vetch (*Astragalus sinicus* L.) cropping system) and FRR (rice-rice cropping system with winter fallow). During the winter, the average daily CO_2 fluxes were greater ($P < 0.05$) in the RRR and CRR than the FRR. During the winter crop growing seasons, both the average daily CO_2 fluxes and the total CO_2 emissions were different as the following orders: RRR > CRR > FRR. The average CO_2 fluxes during early rice and late rice season were similar. The highest CO_2 flux was found at rice tillering stage with an order as the follows: RRR > CRR > FRR and CRR > RRR > FRR both in 2009 and 2010, respectively. The annual CO_2 emissions of RRR and CRR were significantly higher respectively by 857.0 $g \cdot CO_2\text{-}C \cdot m^{-2}$ and 607.4 $g \cdot CO_2\text{-}C \cdot m^{-2}$ than the FRR. The results show that straw recycling of winter cover crops measure may strongly influence the CO_2 emission in paddy field in southern China.

Key words: CO_2 flux, double cropping rice system, paddy field, winter crop.

1. Introduction

Soil is one of the main sources and sinks of GHGs (greenhouse gases) that cause global warming [1]. Increased concentration of CO_2 (carbon dioxide) in the atmosphere (0.4%-0.5% per year) has been linked to the projected warming of world climate [2]. The CO_2 emission from soil to the atmosphere, a primary mechanism of C (carbon) loss from soil, is attributed to the metabolism of plant roots, microflora and fauna [3]. The flux of CO_2 between the atmosphere and the soil is an important link in the global C cycle. Soil respiration rates are controlled by several factors, including soil temperature, quantity and quality of SOM (soil organic matter), soil moisture, the CO_2 concentration gradient between the soil and the atmosphere, pore size distribution and wind speed [4, 5]. In addition, CO_2 emissions are influenced by practices, such as tillage, residue management, crop rotation and ecosystem managements [6, 7].

Winter cover crops, which are grown during an otherwise fallow period, are one possible mean of improving nutrient dynamics in the surface layer of intensively managed crop systems. Further potential benefits of winter cover crops are the prevention of nitrate leaching [8], weed infestation [9], and the improvement of soil water retention, soil organic matter content and microbial activity [10, 11]. Recycling of crop residues has been suggested to improve overall soil conditions, reduce the input of N fertilizer and support sustainable rice (*Oryza sativa* L.) productivity. In particular, Chinese milk vetch (*Astragalus sinicus* L.) and ryegrass (*Lolium multiflorum* L.) were main winter cover crops in

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China. Hermawan and Bomke [12] suggested that winter cover crops, such as annual ryegrass, may protect aggregate breakdown during winter resulting in a better soil structure after spring tillage operation when compared to the bare soil.

In recent years, many researches have studied the effects of winter cover crops on soil physical properties and crop productivity, CH_4 (methane) emission, N (nitrogen) availability and N surplus [13-15]. However, relatively few studies have been conducted in double-cropping paddy field in southern China related to CO_2 emissions under different winter cover crops and double rice treatments. Monitoring CO_2 emissions of different winter cover crops with a double cropping rice system is important to maintain soil productivity, to increase C storage, and to mitigate the greenhouse effects. Therefore, the objectives of this research were to observe the effects of straw recycling of winter cover crops measure on CO_2 emission from paddy field of double cropping rice system in southern China.

2. Materials and Methods

2.1 Site Description

The study was conducted at the experimental station of the Institute of Soil and Fertilizer, Hunan Academy of Agricultural Science in October 2008. The station located in Gansha town (28°08′18″ N, 113°12′0″ E). Hunan province, southern China. The typical cropping system in this area is double cropping rice system (two rice per year). The altitudes of the station is 42 m, and the soil type is a Fe-accumuli-Stagnic Anthrosols derived from Quaternary red clay (clay loam). The characteristics of surface soil (0-20 cm) were as follows: pH 5.20, SOC 17.40 $g \cdot kg^{-1}$, total nitrogen 1.99 $g \cdot kg^{-1}$ (available nitrogen 177.0 $mg \cdot kg^{-1}$), total phosphorous 0.63 $g \cdot kg^{-1}$ (available phosphorous 23.5 $mg \cdot kg^{-1}$), total potassium 8.1 $g \cdot kg^{-1}$ (available potassium 126.0 $mg \cdot kg^{-1}$), all of which were sampled in 2008 prior to the experiment. The area belongs to the subtropical monsoonal humid climate with a long hot periods and short cold periods. Mean annual precipitation is approximately 1500 mm, annual mean temperature is 17.1 °C, the ≥ 10 °C activities accumulative temperature varies from 5,300 °C to 6,500 °C, and annual frost-free period is approximately from 270 day to 310 day. For the study period, October 2008 to October 2010, the daily precipitation and mean temperature data are presented in Fig. 1.

2.2 Experimental Design and Field Management

Three treatments were conducted in this experimental field, including RRR (rice-rice-ryegrass cropping system), CRR (rice-rice-Chinese milk vetch cropping system) and FRR (rice-rice cropping system with winter fallow), using a randomized block design with three replicates. The plot size was 24.0 m^2 (4 m × 6 m). Between the adjacent plots, a 30 cm wide and 25-30 cm high field ridge was constructed and covered with plastic film to defend water penetration and nutrition exchange. The ryegrass (*Lolium multiflorum* L.) variety Duohua and the Chinese milk vetch (*Astragalus sinicus* L.) variety Ningbodaqiao were used as winter cover crops in this study. Before the sowing of winter cover crops, 75.0 $kg \cdot ha^{-1}$ N (163.0 kg urea) and 45.0 kg P_2O_5 (375.0 kg di-ammonium phosphate) were applied as basal fertilizer. The variety of early rice (*Oryza sativa* L.) Zhuliangyou 211 and the variety of late rice (*Oryza sativa* L.) Fengyuanyou 299 were transplanted in 2009 and 2010. During the winter, the no-tillage was adopted in all the treatments. During the rice growing seasons, the soil management regimes were the same among the three use types. The practices of fertilization and soil management were presented in Tables 1 and 2.

2.3 Gas Sampling and Measurements of CO_2

Carbon dioxide was collected by using the static chamber-GC technique at 9:00-11:00 a.m. with the frequency of approximately at 5-6 days after sowing winter cover crops, transplanting early and late rice

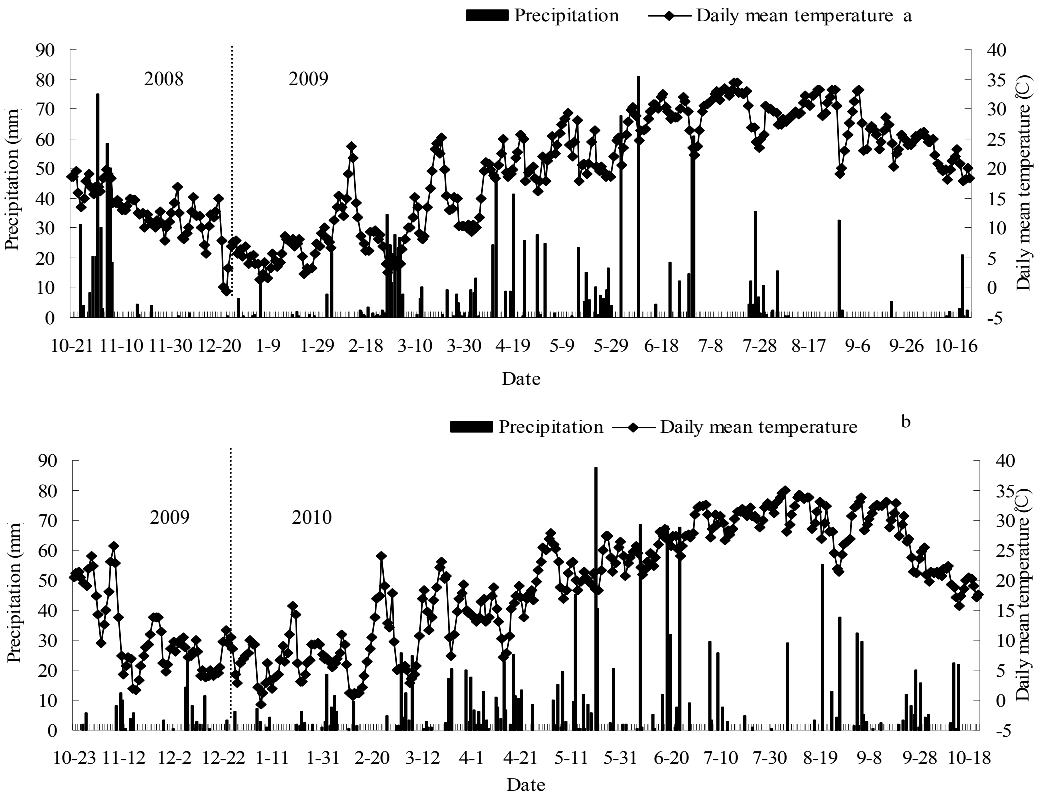

Fig. 1 Daily precipitation and daily mean temperature in (a) 2008-2009 and (b) 2009-2010 in the study site.

Table 1 Agronomic practices of fertilization and soil management for the different cropping systems.

Crop	Date (mm/dd) 2008-2009	Date (mm/dd) 2009-2010	Agronomic practices
Ryegrass and Chinese milk vetch	10/20	10/22	Ryegrass and Chinese milk vetch seeding, sowing rates were 22.5 kg·ha^{-1} and 37.5 kg·ha^{-1}, respectively
	12/5	12/7	Applying 27.6 kg N·ha^{-1} for ryegrass and Chinese milk vetch treatments
	12/10	12/13	Applying 32.4 kg P_2O_5·ha^{-1} for Chinese milk vetch treatment
	2/5	2/10	Ryegrass were clipped the first time and applying 27.6 kg·N·ha^{-1}
	3/7	3/10	Ryegrass were clipped at second time and applying 27.6 kg·N·ha^{-1}
	4/23	4/22	Winter cover crops were harvested and moldboard plow with part of crops straw incorporated into soil, the amount of ryegrass and Chinese milk vetch straw returning were 22,500.0 kg·ha^{-1} and 22,500.0 kg·ha^{-1}, respectively. The depth of tillage was 20 cm.
Early rice	4/10	4/12	Sowing and seedling raising
	5/5	5/6	Paddy tillage
	5/7	5/8	Transplanting (20 cm × 30 cm)
	5/14	5/15	Urea was applied at 150.0 kg·ha^{-1} for top-dressed at tillering
	6/2–6/10	6/3–6/11	Drained out water and dried the soil at maximum tillering stage
	6/11–7/17	6/12–7/18	Wetting-drying alternation irrigation
	7/22	7/23	Grains were harvested
Late rice	7/2	7/4	Sowing and seedling raising
	7/23	7/24	Paddy tillage (The rate of early rice straw returning was 4,500.0 kg·ha^{-1})
	7/24	7/25	Transplanting (20 cm × 30 cm)
	7/31	8/1	Urea was applied at 192.0 kg·ha^{-1} for top-dressed at tillering
	8/22–9/1	8/23–9/2	Drained out water and dried the soil at maximal tillering stage
	9/2–10/17	9/3–10/18	Wetting-drying alternation irrigation
	10/21	10/22	Grains were harvested

Table 2 Fertilization amount and time for the different treatments in early and late rice.

Treatment	Early rice		Late rice	
	Nutrient content of different winter cover crops ($kg \cdot ha^{-1}$)	Applied amount of fertilizer ($kg \cdot ha^{-1}$)	Total amount of applied fertilizer ($kg \cdot ha^{-1}$)	Total amount of applied fertilizer ($kg \cdot ha^{-1}$)
RRR	N,22.3; P_2O_5,3.4; K_2O,39.1	N,127.7; P_2O_5,41.6; K_2O,73.4	N,150; P_2O_5,45; K_2O,112.5	N,180; P_2O_5,45; K_2O,112.5
CRR	N,22.4; P_2O_5,3.4; K_2O,39.6	N,127.6; P_2O_5,41.6; K_2O,72.9	N, 150; P_2O_5,45; K_2O,112.5	N,180; P_2O_5,45; K_2O,112.5
FRR	N,5.6; P_2O_5,1.2; K_2O,15.0	N,144.4; P_2O_5,43.8; K_2O,97.5	N, 150; P_2O_5,45; K_2O,112.5	N,180; P_2O_5,45; K_2O,112.5

RRR, rice-rice-ryegrass cropping system; CRR, rice-rice-Chinese milk vetch cropping system; FRR, rice-rice cropping system with winter fallow. The same as below.

for the entire monitoring period. The chamber (50 cm × 50 cm × 120 cm, length × width × height) and its base were made of PVC board. There was a groove in the collar which corresponded to the chamber. The base was inserted into the soil at a depth of about 5 cm (the groove was 1 cm below the flooded water) before testing. During the observation period, the chamber was put into the groove of the collar with water to prevent leakage, and the winter cover crops and rice were planted in the base of chamber. The chamber contained a small fan for stirring air, a thermometer sensor and a trinal-venthole. Before CO_2 sample collection, the fan located on the top of chamber was turned on to evenly mix the air in the chamber. The injector with 50 mL volume was used to extract air samples at 0, 10, 20 and 30 min after closing the box, respectively. The air samples were transferred to 0.5 L sealed sample bags by rotating a trinal-venthole.

The concentration of CO_2 in a gas sample was measured by a gas chromatographer (Agilent 7890A) equipped with a FID (flame ionization detector) and an ECD (electron capture detector). N_2 was used as the carrier gases and an Ar-CH_4 gas mixture as the make-up gas for ECD analysis of CO_2. CO_2 was detected by FID, the oven temperature was controlled at 55 °C, and the temperature of the FID was set at 200 °C.

The data of nutrient content of different winter cover crops and applied amount of fertilizer are presented as averages of the 2 years.

The soil CO_2 fluxes expressed as $mg \cdot CO_2\text{-}C \cdot m^{-2} \cdot h^{-1}$ were calculated with the Eq. (1) [16]:

$$F = \rho \times V/A \times \Delta c/\Delta t \times 273/T \times \alpha \quad (1)$$

where, F ($mg \cdot CO_2\text{-}C \cdot m^{-2} \cdot h^{-1}$) is the soil respiration rate; ρ is the density of CO_2 (1.98×10^3 $g \cdot m^{-3}$) under standard condition; V (m^3) and A (m^2) are the volume and bottom areas of the chamber, respectively. Δc ($m^3 \cdot m^{-3}$) is the change in CO_2 concentration in the chamber during the period Δt (h); T is the air temperature (°C) inside the chamber; α is the conversion factor for CO_2 to C (12/44).

The total emissions of CO_2 over the winter cover crops and rice growth season were sequentially accumulated from the emissions averaged on every two adjacent intervals of the measurements [17].

Data presented herein are means of three replications per treatment. All data were expressed as means plus or minus on standard error. All the statistical analyses were performed by using the SPSS 11.0 package [18]. Differences between the treatments were examined using a one-way ANOVA (analysis of variance). Differences among the treatments means were compared using the LSD (least significant difference) test at $P < 0.05$.

3. Results

3.1 Dynamics of CO_2 Flux

3.1.1 Dynamic of CO_2 Flux from Paddy Field during Winter

During the period of October 22 to April 22, the flux of CO_2 emission varied with winter use types as the order of RRR > CRR > FRR. The CO_2 flux gradually increased from the beginning of the experiment in February and peaked on Mar. 17, 2009

and on Mar. 19, 2010, respectively. The CO_2 fluxes ranged from 71.2 mg·CO_2-C·m^{-2}·h^{-1} to 544.8 mg·CO_2-C·m^{-2}·h^{-1} in 2009 (Fig. 2a). According to the frequency analysis, the mean fluxes were 245.5, 182.1 and 136.0 mg·CO_2-C·m^{-2}·h^{-1} in the three treatments of RRR, CRR and FRR, respectively (Fig. 2a) in 2009. The CO_2 fluxes ranged from 20.5 mg·CO_2-C·m^{-2}·h^{-1} to 709.5 mg·CO_2-C·m^{-2}·h^{-1} in 2010 (Fig. 2b), and the mean values were 276.8, 204.9 and 145.0 mg·CO_2-C·m^{-2}·h^{-1} under the treatments of RRR, CRR and FRR, respectively in 2010 (Fig. 2b).

3.1.2 Dynamic of CO_2 Flux from Paddy Field during Rice Growth Period

In the early rice season, the CO_2 flux rate peaked about 14-28 days after transplanting, dramatically decreased and remained at a relatively low rate till another little peak at about 35-36 days after transplanting (Figs. 2a and 2b). The peak of CO_2 under RRR and CRR was higher (P < 0.05) than that under FRR. The difference of CO_2 emission rate among the treatments was significant in the early rice tested by ANOVA.

In the late rice season, the peak of CO_2 flux appeared 14-28 days after transplanting, which was almost the same as the early rice (Figs. 2a and 2b). The maximum emission rate was 777.8 mg·CO_2-C·m^{-2}·h^{-1} and 886.2 mg·CO_2-C·m^{-2}·h^{-1} under RRR and CRR in 2009, respectively (Fig. 2a). The emission rate decreased dramatically and remained at a lower released rate. The maximum emission rate was 782.2 mg·CO_2-C·m^{-2}·h^{-1} and 957.4 mg·CO_2-C·m^{-2}·h^{-1} under RRR and CRR in 2010, respectively (Fig. 2b). The CO_2 emission rate under FRR was significantly lower (P < 0.05) than RRR and CRR in the late rice.

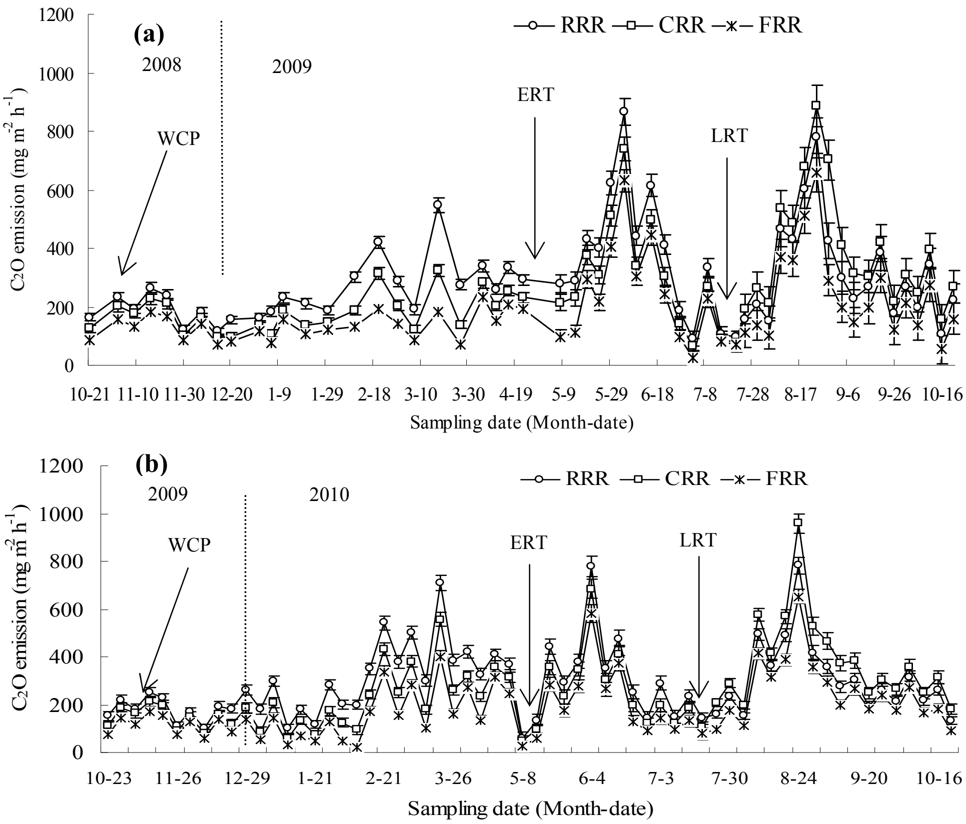

Fig. 2 Seasonal dynamic of CO_2 emissions rate in winter cover crops, early and late rice fields in (a) 2009 and (b) 2010. RRR, rice-rice-ryegrass cropping system; CRR, rice-rice-Chinese milk vetch cropping system; FRR, rice-rice cropping system with winter fallow; WCP: winter cover crop planted; ERT: early rice transplanting; LRT: late rice transplanting. Values are means ± SE (n = 3). Means in each column with different letters are significantly different at P < 0.05 level.

3.2 Total CO_2 Emission during Winter Cover Crop Growing Seasons

During the winter crop growing seasons, the total amount of CO_2 emission was 1,072.3 g·CO_2-C·m^{-2} and 795.2 g·CO_2-C·m^{-2} under RRR and CRR, respectively (Table 3), which were correspondingly 80.5% and 33.8% higher than that of the FRR. The total CO_2 emissions was 1,215.5 g·CO_2-C·m^{-2} and 900.1 g CO_2-C·m^{-2} under RRR and CRR from October 2009 to May 2010, respectively (Table 3), which were correspondingly 88.3% and 39.5% higher than that of the FRR.

3.3 Total CO_2 Emission during Rice Growing Seasons

In the early and late rice seasons both in 2009 and 2010, the total CO_2 emission under RRR and CRR was significantly higher ($P < 0.05$) than that of FRR, the sequence of total CO_2 emission was RRR > CRR > FRR in early rice, and the sequence of total CO_2 emission was CRR > RRR > FRR in late rice (Table 4).

In 2009, the total amounts CO_2 emission was 587.5 g·CO_2-C·m^{-2} and 475.5 g·CO_2-C·m^{-2} under RRR and CRR in early rice, respectively. The total amounts of CO_2 emission was 655.2 g·CO_2-C·m^{-2} and 798.2

Table 3 Total CO_2 emission during the seasons of winter crop growing.

Years	Treatment	CO_2 emission (g·CO_2-C·m^{-2})
2008-2009	RRR	1072.3 ± 30.3 a
	CRR	795.2 ± 22.5 b
	FRR	594.1 ± 16.8 c
2009-2010	RRR	1215.5 ± 35.1 a
	CRR	900.1 ± 26.0 b
	FRR	645.4 ± 18.6 c
Average	RRR	1143.9 ± 33.0 a
	CRR	847.7 ± 24.5 b
	FRR	619.8 ± 17.9 c

Table 4 Total CO_2 emission during the seasons of rice growing (g·CO_2-C·m^{-2}).

Years	Treatment	Transplanting-Initial tillering stage	Initial tillering stage-full tillering stage	Full tillering stage-boot stage	Boot stage-complete panicle stage	Complete panicle stage-maturity stage	Total
2009	Early rice						
	RRR	87.6 ± 2.5a	236.5 ± 6.8a	152.6 ± 4.4a	43.2 ± 1.3a	67.6 ± 2.0a	587.5 ± 16.9a
	CRR	72.4 ± 2.1b	197.5 ± 5.7b	118.9 ± 3.4b	32.2 ± 0.9b	54.5 ± 1.6b	475.5 ± 13.7b
	FRR	44.4 ± 1.3c	157.4 ± 4.6c	102.7 ± 3.0c	24.4 ± 0.7c	43.8 ± 1.3c	372.7 ± 10.8c
	Late rice						
	RRR	41.3 ± 1.2b	218.6 ± 6.3b	132.2 ± 3.8b	76.4 ± 2.2b	186.7 ± 5.4b	655.2 ± 18.9b
	CRR	53.8 ± 1.6a	248.3 ± 7.2a	176.0 ± 5.1a	98.9 ± 2.9a	221.2 ± 6.4a	798.2 ± 23.0a
	FRR	27.8 ± 0.8c	182.4 ± 5.3c	100.9 ± 2.9c	52.2 ± 1.5c	137.9 ± 4.0c	501.2 ± 14.5c
2010	Early rice						
	RRR	71.5 ± 2.1a	192.9 ± 5.6a	103.8 ± 3.0a	33.3 ± 1.0a	93.3 ± 2.7a	494.8 ± 14.3a
	CRR	55.6 ± 1.6b	165.2 ± 4.8b	87.7 ± 2.5b	26.8 ± 0.8b	70.1 ± 2.0b	405.4 ± 11.7b
	FRR	41.6 ± 1.2c	134.3 ± 3.9c	73.5 ± 2.1c	18.5 ± 0.5c	51.5 ± 1.5c	319.4 ± 9.2c
	Late rice						
	RRR	47.9 ± 1.4b	204.2 ± 5.9b	149.4 ± 4.3b	90.2 ± 2.6b	175.2 ± 5.1b	666.9 ± 19.3b
	CRR	61.2 ± 1.8a	241.4 ± 6.9a	187.4 ± 5.4a	117.5 ± 3.4a	211.1 ± 6.1a	818.6 ± 23.6a
	FRR	34.1 ± 1.0c	169.9 ± 4.9c	125.6 ± 3.6c	72.9 ± 2.1c	143.1 ± 4.1c	545.6 ± 15.8c

Values are means ± SE (n = 3).
Means in each column with different letters are significantly different at $P < 0.05$ level.

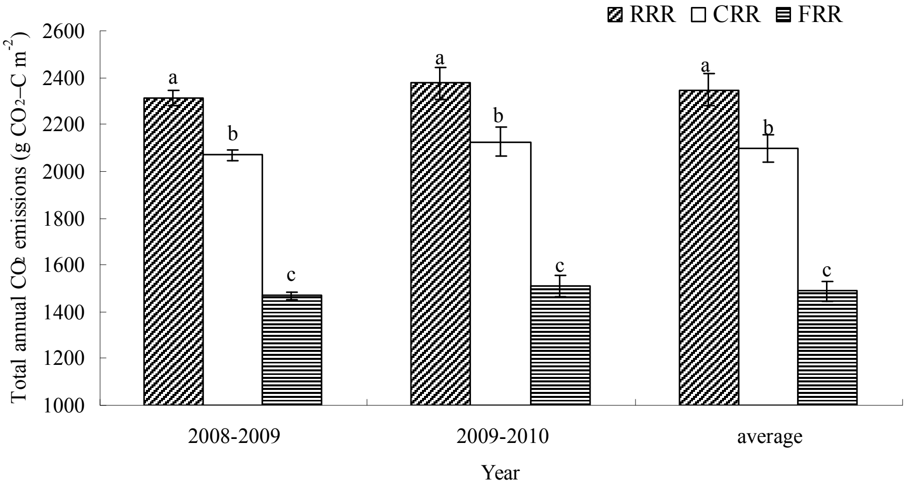

Fig. 3 Total annual CO_2 emissions under different cropping systems in 2008-2010. Error bars represent standard error of mean. Different letters are significantly different at *P* < 0.05 level.

g·CO_2-C·m^{-2} under RRR and CRR in late rice, respectively (Table 4). In 2010, the total CO_2 emission was 494.8 g·CO_2-C·m^{-2} and 405.4 g·CO_2-C·m^{-2} under RRR and CRR in early rice, respectively, and the total CO_2 emission was 666.9 g·CO_2-C·m^{-2} and 818.6 g·CO_2-C·m^{-2} under RRR and CRR in late rice, respectively (Table 4).

3.4 Total Annual CO_2 Emissions

For the entire monitoring period, the annual total CO_2 emission from paddy fields with different treatments was RRR > CRR > FRR (Fig. 3). Compared to FRR, the annual total CO_2 emission was increased by 57.7% and 40.9% under RRR and CRR from October 2008 to October 2009, and was increased by 57.4% and 40.6% from October 2009 to October 2010, respectively (Fig. 3).

4. Discussion

4.1 CO_2 Emission of Winter Cover Crops

In our experiment, air and soil temperature seasonal variations in CO_2 fluxes for all management practices, the highest fluxes during summer due to the high temperature and biological activity, and the lowest fluxes during winter in which soil biological activity is lowest due to suboptimal soil temperatures. Jacinthe et al. [19] showed that the intensity of CO_2 emission was higher in the late winter and summer seasons than that of other time. In our study, during the seasons of winter crop growing, CO_2 fluxes in the early growth stage were lower than those in the later growth stage. Lower CO_2 emissions during winter could be attributed to minimal soil biological activity due to low soil temperatures [20]. The lowest flux was recorded in December, coinciding with the lowest air temperatures (Fig. 1), while the highest fluxes occurred on March 17-19, following with the N fertilizer and air temperature increase. Across the experimental duration, the average fluxes under RRR and CRR were significantly higher than that under FRR. This could be related to the differences in the winter use patterns and crop growth duration. Meanwhile, it showed that the different fertilizer rates were designed for the two winter crops but no fertilizers were applied for the fallow treatment. This may be due to differences in soil nutrient concentrations and C/N ratios among the treatments, which would affect CO_2 emission [13]. The seasonal average of CO_2 fluxes was higher in the RFF than CFF treatment during the winter cover crops growth period, and this could be attributed to ryegrass growth, physiological activities and soil respiration improved by harvested twice and application with 27.6 kg N·ha^{-1}. Ngonidzashe et al. [21] showed that cumulative soil

CO_2 emissions from soils under winter wheat ranged between 1787 kg·CO_2-C·ha^{-1} and 2935 kg·CO_2-C·ha^{-1}. In the present study, the total CO_2 emissions were significantly lower under FRR than under RRR and CRR treatments. The seasonal amount of CO_2 emission suggested that, on average, RRR and CRR treatments emitted respectively 524.1 g·CO_2-C·m^{-2} and 227.9 g·CO_2-C·m^{-2} more than FRR. The results show that the CO_2 fluxes and total CO_2 emissions varied with different winter use types in the order: RRR ＞ CRR ＞ FRR during the seasons of winter crop growing. This was likely because of the differences in the use types and winter crop growth.

4.2 CO_2 Emission during Rice Growing Period

The CO_2 evolution in soils is controlled by both biotic and abiotic factors. The biotic factors include type, mass and activity of microorganisms, the abiotic factors include soil and air temperatures, soil water content, porosity, nutrients and SOC concentrations [6, 20, 22, 23]. Soil management practices can alter both the biotic and abiotic factors which affect CO_2 formation in soils. The CO_2 fluxes observed in this study were temporally variable and were significantly affected by different winter use patterns. The average CO_2 fluxes during the seasons of early rice growing and late rice growing were similar (Fig. 2). During the early rice growing season, CO_2 fluxes under FRR were generally lower than those of RRR and CRR. Higher CO_2 emission from RRR and CRR compared to FRR in this study could be attributed to (1) decomposition of winter cover crop residues placed on the soil under the RRR and CRR; (2) different organic inputs (winter cover crop residue); (3) soil thermal and hydraulic properties and processes related to soil microbial activity and SOM decomposition; (4) crop growth and root respiration.

In this study, the largest CO_2 flux was observed at 14-28 days after transplanting during the early and late rice seasons, and the orders were RRR > CRR > FRR and CRR > RRR > FRR (Fig. 2), respectively. The CO_2 fluxes were generally lower and remained at a lower rate among the RRR, CRR and FRR treatments during the later period of rice growth. These trends in CO_2 flux were similar to those reported in other studies [23, 24]. CO_2 fluxes of RRR were higher than CRR during early rice season, and the cause perhaps was that ryegrass straw were ploughed into soil to result in a rapid decomposition. CO_2 fluxes of CRR were higher than RRR during the late rice season, and the cause perhaps was that Chinese milk vetch straw were ploughed into soil to result in a rapid decomposition. Increased CO_2 fluxes were attributed to the differences in seasonal temperature. In this study, increased CO_2 fluxes in rice season were consistent with higher air temperatures during rice season. Increase in CO_2 flux with increase in temperature is attributed to increase in soil respiration [23]. The CO_2 flux rate peaked about 2-4 weeks after transplanting, which were coincided with fertilizer (N) application after transplanting and highest air temperature (Figs. 1 and 2).

The seasonal variation in CO_2 fluxes is noteworthy and reflects climatic controls on CO_2 production and emission, and the modulating effect of soil cover on these processes. Franzluebbers et al. [22] reported that increased CO_2 emissions from soil attributed to higher SOC content under no-tillage which favored increased microbial decomposition. Our experiment showed that total CO_2 emissions were effected by winter use patterns. Total CO_2 emissions under RRR and CRR in rice season were significantly higher than under FRR (Fig. 3). This could be related to the difference of winter crops straw types, straw returning rates and straw decomposition rates. Recycling of cereal straw is considered as a sustainable crop management practice because of its positive effects on soil chemical, physical and biological properties. In this study, during the late rice season, CO_2 emission from paddy fields was increased by partial return of early rice straw, and the soil respiration was improved. The sequence of CO_2 flux and total CO_2 emission from

late-rice paddy fields were different due to the different rate of winter cover crops straw returning (Table 1) and straw decomposition during late rice season.

5. Conclusions

This study aimed to evaluate CO_2 emissions in double cropping rice area of southern China by using RRR, CRR, FRR treatments and continuous winter cover crops and double cropping rice rotation system for two year. During the seasons of winter crop growth and rice growth, the average CO_2 fluxes of RRR and CRR were significantly greater than the FRR. During the seasons of winter crop growth, the flux of CO_2 varied with different winter cover crops in the order: RRR > CRR > FRR. During the rice season, the order of average CO_2 flux with different treatments was following: RRR > CRR > FRR, CRR > RRR > FRR during the early rice and the late rice seasons, respectively. These results indicate that the average CO_2 fluxes were affected by winter use patterns during rice season. Adoption of RRR and CRR increased CO_2 emission in paddy field. On an annual basis, RRR and CRR increased CO_2 emissions by 857.0 $g{\cdot}CO_2\text{-}C{\cdot}m^{-2}$ and 607.4 $g{\cdot}CO_2\text{-}C{\cdot}m^{-2}$ on average compared to the FRR. These results show that CO_2 emission from paddy soils was influenced by ryegrass and Chinese milk vetch straw returning. In our experiment, the emission of CO_2 from paddy field was including the soil and plant respiration. CO_2 emissions are influenced by several factors, including soil physico-chemical parameters, microbial and plant. Therefore, we should be taking into account the soil physico-chemical parameters, soil microbial population or otherwise the plant biomass derived CO_2 emissions. However, long-term studies are needed to examine the CO_2 emissions from paddy soils in the rice-rice-winter crop cropping system.

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In Vitro Propagation of *Echeveria elegans*, a Species of the Flora Endangered Mexican

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Abstract: The genus *Echeveria* has about 143 species that are unique to the Americas, 117 of which are presented in the Mexican Republic, mainly in the states of Hidalgo, Puebla and Oaxaca. Propagation can be done by cuttings, leaf cuttings or seeds, but these methods are insufficient to avoid the predation of many species. NOM-059-ECOL-2001 shows *Echeveria elegans* as species reported endangered. The objectives in this study were achieved *in vitro* propagation from axillary buds, as an alternative to multiplication and preservation species. We evaluated different concentrations and combinations of two growth regulators, 6-BAP (2.22, 4.44, 6.66 and 8.88 µM) and α-NAA (1.35 and 2.70 µM) on shoot formation from axillary buds and two culture media with different concentrations of MS salts, to achieve root plants grown *in vitro*. It was found by combining 6.66 µM of 6-BAP and 1.35 µM of α-NAA favored the formation and development of new shoots. In the rooting stage, the best results are achieved with the treatment containing 50% of MS salts. Then the plants were transplanted into greenhouses and achieved a successful acclimatization. During this last phase of development, there were no phenotypic changes or presence of somaclonal variants.

Key words: *Echeveria*, propagation, growth regulators, axillary bud.

1. Introduction

The genus *Echeveria* is within the family Crassulaceae, which has about 143 species unique to the Americas. A total of 117 are present in the Mexican Republic, mainly in the states of Hidalgo, Puebla and Oaxaca [1].

Echeveria elegans is characterized by rosette-shaped plants with fleshy leaves green-blue for its unique feature of generating cuttings around the base of the rosette, which is known as "Hen and Chicks" [2].

Human activities such as change in soil use, indiscriminate commercial exploitation and environmental crisis, are the main causes that have made *E. elegans* endangered as reported in NOM-059-SEMARNAT-2001 [3, 4].

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Propagation can be done by leaves cuttings or seed, but these methods are insufficient against predation suffering for their ornamental value. That is why until 2007 little research is reported about in vitro propagation methods different from those traditionally used such as germination [1].

There are reports on Crassulacean tissue culture such as *Bryophyllum calycium*, *Crassula ovata*, *Crassula helmsii*, *Kalanchoe spp.*, *Graptopetalum spp.*, and *Sempervivum tectorum* [5-10]. However, the reports on *Echeveria* propagation only known one to present in a study conducted on *Echeveria derenbergii* [4]. The objectives of this study were obtained *in vitro* propagation of this species from axillary buds, as an alternative to multiplication and preservation.

2. Materials and Methods

Echeveria elegans plants previously established *in vitro* from 3 cm to 4 cm in length used for this work,

and then were cutting 1.5 cm segments of length without the apical meristem, and each explant showed approximately 4 axillary buds. The culture medium used was the basal medium proposed by MS (Murashige and Skoog) [11] supplemented with 2.0 $mg \cdot L^{-1}$ thiamine, 30 $g \cdot L^{-1}$ sucrose, a combination of 6-BAP with α-NAA at different concentrations (Table 1), and the pH was adjusted to 5.7 with KOH and/or HCl, later added 2.5 $g \cdot L^{-1}$ of phytagel as gelling agent. The culture medium was heated to boiling point, dosed 25 mL culture medium per 170 mL glass jar, and the bottles were sterilized by autoclaving for 20 min at 1.2 $kg \cdot cm^{-2}$ pressure and 121 °C.

The work was done under a laminar flow hood in strict aseptic conditions required. Each treatment was performed in eight replicates, each culture flask was placed two explants, and the vials were sealed with plastic tape. The culture flasks with the stems in growth were placed into chamber with a temperature ranging between 28 ± 2.0 °C and a photosynthetic photon flux density of 38-47.5 $\mu mol \cdot m^{-2} \cdot s^{-1}$.

The evaluation of treatments was performed accounting induced buds at 40 days of culture. From the data we calculated the mean and standard deviation also measures of central tendency. To find out if there is a statistically significant difference between treatments. The authors performed the LSD 95%.

Thiamine, pH and the like phytagel remained at the same values as in the propagation medium. The culture and incubation conditions were developed in as in the previous stage. Rooting was evaluated by the root length of the plants at 30 days subculture, calculating the mean and standard deviation.

3. Results and Discussion

The efficient propagation of *Echeveria elegans* is achieved with the combination of two growth regulators in different concentrations (Table 1).

In the statistical analysis from each treatment we found statically significant differences among themselves ($P \leq 0.05$), and identify six homogeneous groups using multiple range test LSD (least significant difference) with 95% confidence, that identify the formation of six homogeneous groups.

Table 1 shows the mean of the data obtained, the best results correspond the treatment 8, and it was supplemented with 6.66 µM of 6-BAP + 1.35 µM of α-NAA after 40 days of culture with an average number of 4.21 shoots per explant, similar to that reported with *Hylotelephium sieboldii* var *ettyuense* in 2005 [12].

Fig. 1B shows that after 15 days of culture activation axillary buds was already evident at 30 days which were observed and shoot formation (Fig. 1C) same to observed in *Kalanchoe tomentosa* obtained in 2006 [8]. The plants obtained in the propagation step are

Table 1 Combinations the growth regulators in the culture medium, multiple ranges test with 95% of confidence.

Treatment	Combinations the growth regulators	Average number of shoots per explant	Homogeneus groups 95% LSD
8	6.66 µM of 6-BAP + 1.35 µM of α-NAA	4.21	A
9	8.88 µM of 6-BAP + 1.35 µM of α-NAA	3.62	AB
5	8.88 µM of 6-BAP + 0 µM of α-NAA	3.62	AB
2	2.22 µM of 6-BAP + 0 µM of α-NAA	3.56	AB
7	4.44 µM of 6-BAP + 1.35 µM of α-NAA	3.18	ABC
3	4.44 µM of 6-BAP + 0 µM of α-NAA	3.06	ABC
4	6.66 µM of 6-BAP + 0 µM of α-NAA	2.42	BCD
6	2.22 µM of 6-BAP + 1.35 µM of α-NAA	2.18	CDE
12	6.66 µM of 6-BAP + 2.7 µM of α-NAA	2.06	CDEF
13	8.88 µM of 6-BAP + 2.7 µM of α-NAA	1.58	DEF
11	4.44 µM of 6-BAP + 2.7 µM of α-NAA	1.37	DEF
1	0 µM of 6-BAP + 0 µM of α-NAA	1.12	EF
10	2.22 µM of 6-BAP + 2.7 µM of α-NAA	1.0	F

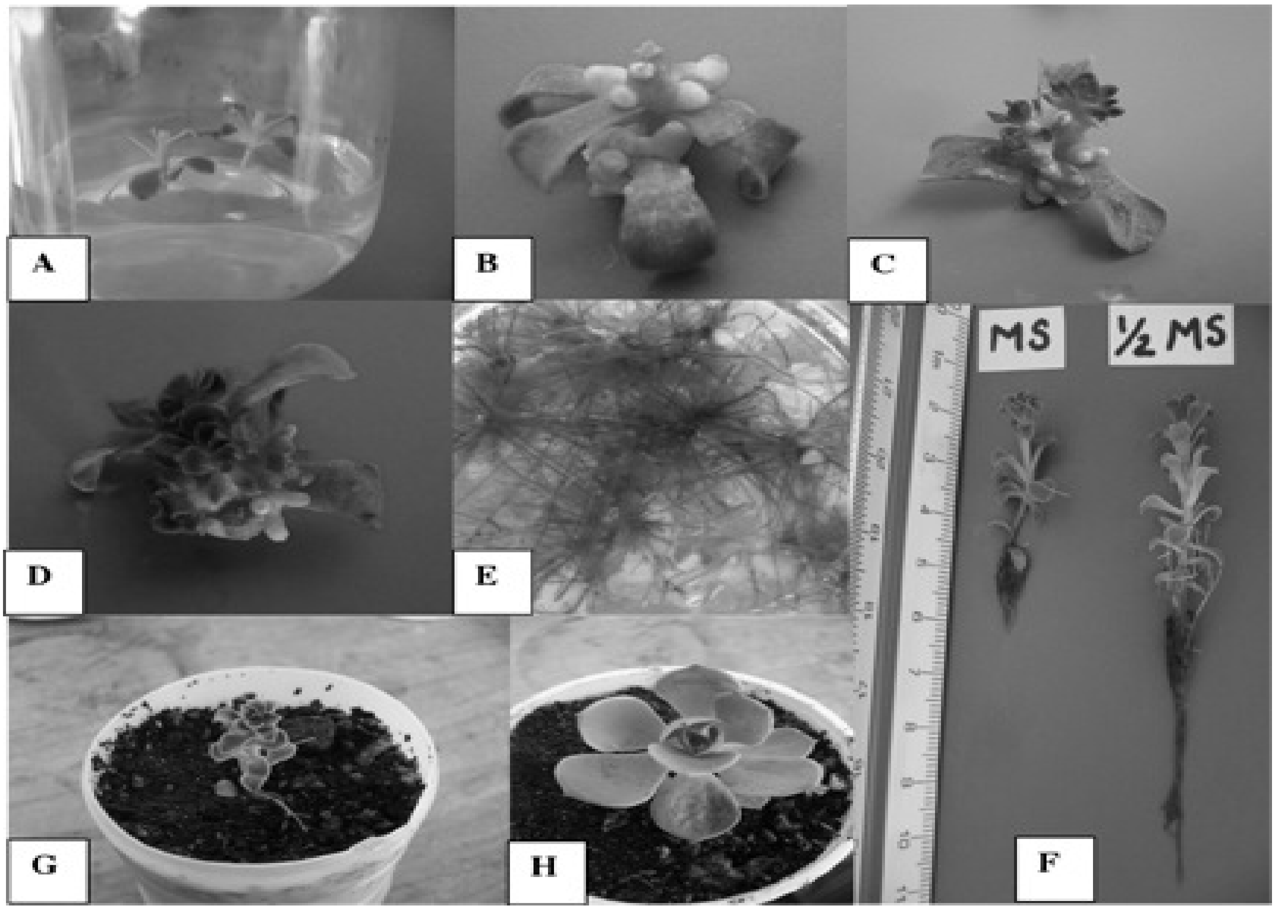

Fig. 1 ***In vitro* propagation of *E. elegans*. (A) Segments that were used as explants stems for cultivation; (B) Activation of axillary buds after 15th day of cultivation in medium containing 6.66 µM of 6-BAP + 1.35 µM of α-NAA; (C) Growth of shoots from axillary buds after 30th day of cultivation; (D) Generation of new plants after 40th day of culture; (E) View of the culture bottle with a rooting medium containing 50% of MS salts; (F) Differences in root growth in rooting media both at 30th day of subculture; (G) Ground acclimatization stage after 15th day in greenhouse; (H) *E. elegans* plant with three months under greenhouse.**

subcultured to a medium for rooting, evaluated two concentrations of inorganic salts proposed by Murashige and Skoog. The salts of first treatment were 100% of force and in the second treatment were reduced to half.

The effect of 6-BAP as promoter of activation in axillary buds was observed in the absence of an auxin such as α-NAA in this study, the generation of new shoots was close to the best treatment, only the case that shoots began to generate hyperhydricity, which instead in treatments presenting a combination of both growth regulators and, were only a few isolated cases of hyperhydricity, therefore, it is advisable to use a combination of auxins and cytokinins prevent this phenomenon or try a different cytokinin.

The control treatment (treatment 1) showed the appearance of apical dominance posing *E. elegans*, in the stem segments used as explants for 20-25 days after the cultivation was observed an outbreak on the top of the stem and roots form subsequently at 95% of the explants. This served as a background for the rooting stage.

The plants generated in the propagation step were subjected to rooting, based on the treatment of stage 1 of the spread, wherein the root explants generated without the influence of any auxin. It was decided to assess two concentrations of salts MS basal medium; in the first treatment the concentration of salts was found strength at 100% and in the second treatment is halved. Fig. 1F shows differences presented in both

treatments, and the treatment showed that the best result was in the rooting medium containing MS salts at 50% strength, with an average length of 35.6 mm to root 30 days after subculture, about 40% greater than those produced with salts of MS 100% strength. Although the goal that was just rooting was also observed that the growth of propagated plant was best, possibly due to a better uptake of nutrients and the root system quality.

The plants obtained in the process of propagation were acclimatized in a greenhouse, for these were prepared to a substrate comprising compost 50% and 50% of tezontle (red stone) to increase the porosity of the substrate, after 15 days field crop was obtained in 94% survival (Fig. 1G). Plants propagated *in vitro* with *ex vitro* acclimatized, after three months of development in the greenhouse no showed change phenotypic, nor any somaclonal variant (Fig. 1H).

4. Conclusion

The current study shows a successful protocol for *in vitro* propagation of *Echeveria elegans* without phenotypic changes and somaclonal variants. Where axillary buds could be used in starting *in vitro* propagation of *E. elegans*, as well as the use of 6.66 μM 6-BAP + 1.35 μM α-NAA and a rooting medium containing 50% of MS salts. This basic protocol provides an effective method for recovery of *E. elegans*, which is in risk of disappearance.

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Thermal Performance Study of Three Models of Solar Air Heater Made of Concrete

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Abstract: An experimental study was conducted on three models of solar collectors having an absorber made of concrete designed and built in the TPL (Thermal Process Laboratory). A sequence of tests was performed on these models for the two air circulation models (forced and natural) in order to compare their thermal performance. The results are presented in terms of useful energy, stored energy and thermal efficiency of each model.

Key words: Solar energy, heat transfer, natural convection, forced convection, solar collector made of concrete.

1. Introduction

Solar energy appears as the energy of the future in terms of energy saving and environmental protection. Given the role it can play in countries like Tunisia, receiving a relatively high exposure, approximately 3,000 h of sunshine annually and an average daily global radiation of 5 kwh/m^2 [1], this energy can be used effectively in areas where the thermal collectors are used to convert solar energy into thermal energy. The efficiency of these collectors in optimum conditions reaches 60%. The applications are mainly of hot water production, heating, drying and desalination.

In this study we focus on three models of a collector type collector solid matrix and which differ in the nature of air flow path in the collector.

2. System Description

This type of sensor consists of concrete absorber of 4 cm thickness placed in an aluminum box of dimensions (2 m × 1 m × 0.15 m) with a polyurethane insulation of 3 cm thick. The set is covered by tempered glass 4 mm thickness. The collector has two inlet and two outlet vents on both sides of the absorber (Fig. 1).

The three models studied are:

(1) Model (A) double inlet and double outlet (air circulates between the glass and the absorber in the holes and between the absorber and insulation in the rear channels);

(2) Model (B) one inlet and one outlet (air enter over the absorber and leave below it through the holes);

(3) Model (C) one inlet and one outlet (air enter below the absorber and leave above it through the holes).

3. Theoretical Study

Thermal performance evaluation of these models requires measurement of the following data:

(1) The incident solar radiation measured using a pyranometer (Kipp Zonen);

(2) Ambient temperatures (*Ta*), glass temperature (*Tv*) absorber surface temperature (*Tsa*), absorber bottom temperature (*Tia*), air canal temperature (*Tc*) input and outlet air temperature (*Te*, *Ts*) measured with thermocouples type K;

(3) The speed and humidity at the collector output measured using a hot wire anemometer.

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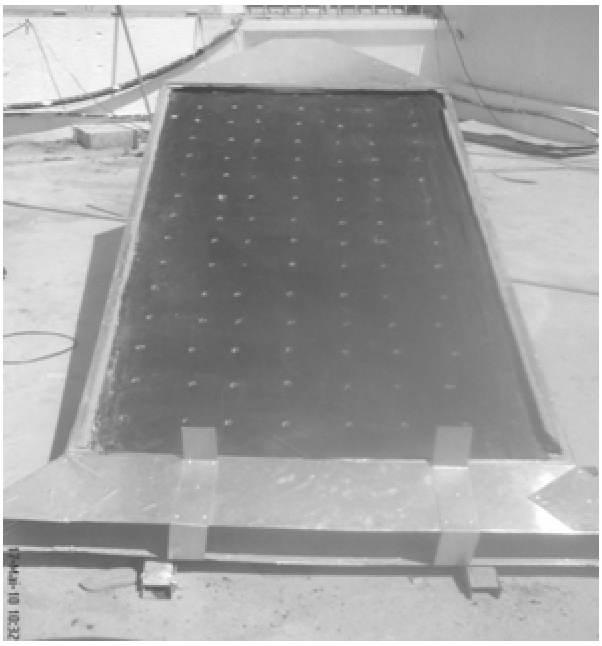

Fig. 1 The solar air heater made of concrete.

Data acquisition control takes place through an acquisition chain (HP34970A Agilent Technology) using a program written in HP-VEE;

The measurement campaign was performed at the TPL (Thermal Processes Laboratory) during six days for the three models A, B and C and both modes of air circulation (forced-f-and natural-n-) [2].

Step 1: Between 9 a.m. and 13 p.m. on the collector is exposed to the sunlight and the different temperatures and radiation measurement begin after 15 minutes to determine the energy delivered by the collector during this period and the evolution of the different temperatures in the collector components.

Step 2: (destocking phase): After 13 h the collector is covered by insulation and a temperature measurement of inputs and outputs is done to determine the stored energy in the collector.

To estimate the efficiency of the three collector models we define the thermal performance, for both circulation modes which is the ratio of useful energy, plus the stored energy over the energy received by the collector [3].

$$\eta = \frac{q_u + q_{st}}{H} \tag{1}$$

Knowing the input and output air temperatures in the collector q_u and q_{st} can be determined:

$$q_u = q_{st} = \frac{\dot{m}c_p}{A_c} \Delta t \sum \left(T_{fs} - T_{fe}\right) \tag{2}$$

with

$$\dot{m} = \rho \cdot Vs \cdot Ss$$

The thermal energy received by the collector is:

$$H = Qr \cdot \Delta t \tag{3}$$

4. Results and Discussion

The results are given in the different figures showing temperature and radiation temperature evolution and the table giving the useful and stored energy, incident radiation and the thermal efficiency for each type of collector for both air circulation mode.

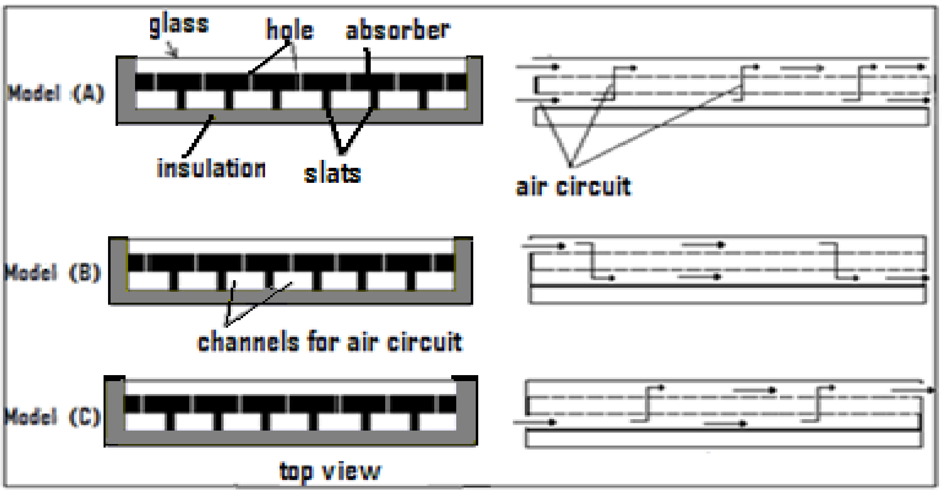

Fig. 2 Three models (A, B and C) of solar air heater made of concrete.

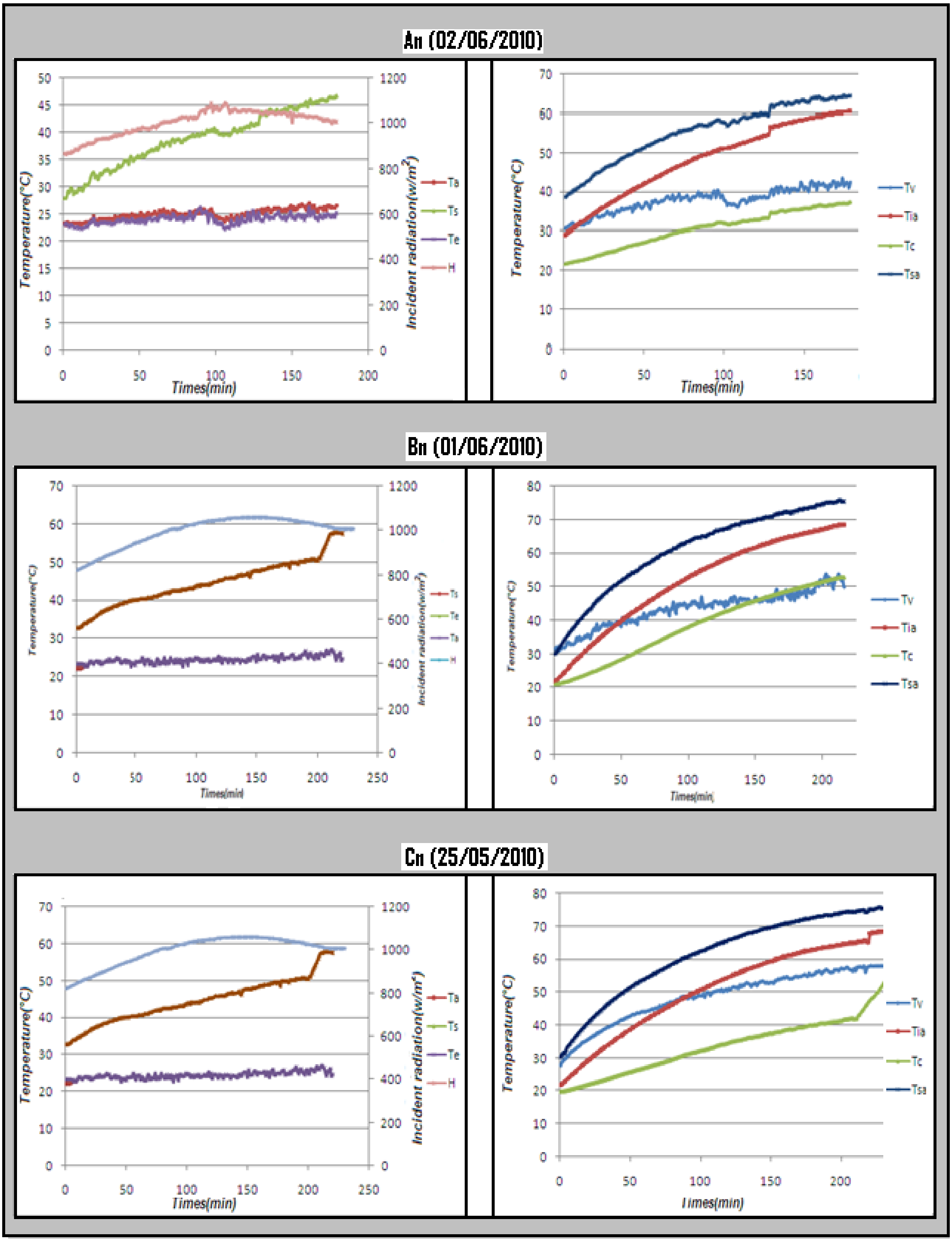

Fig. 3 Temperature and radiation temporal evolution for three models in natural convection.

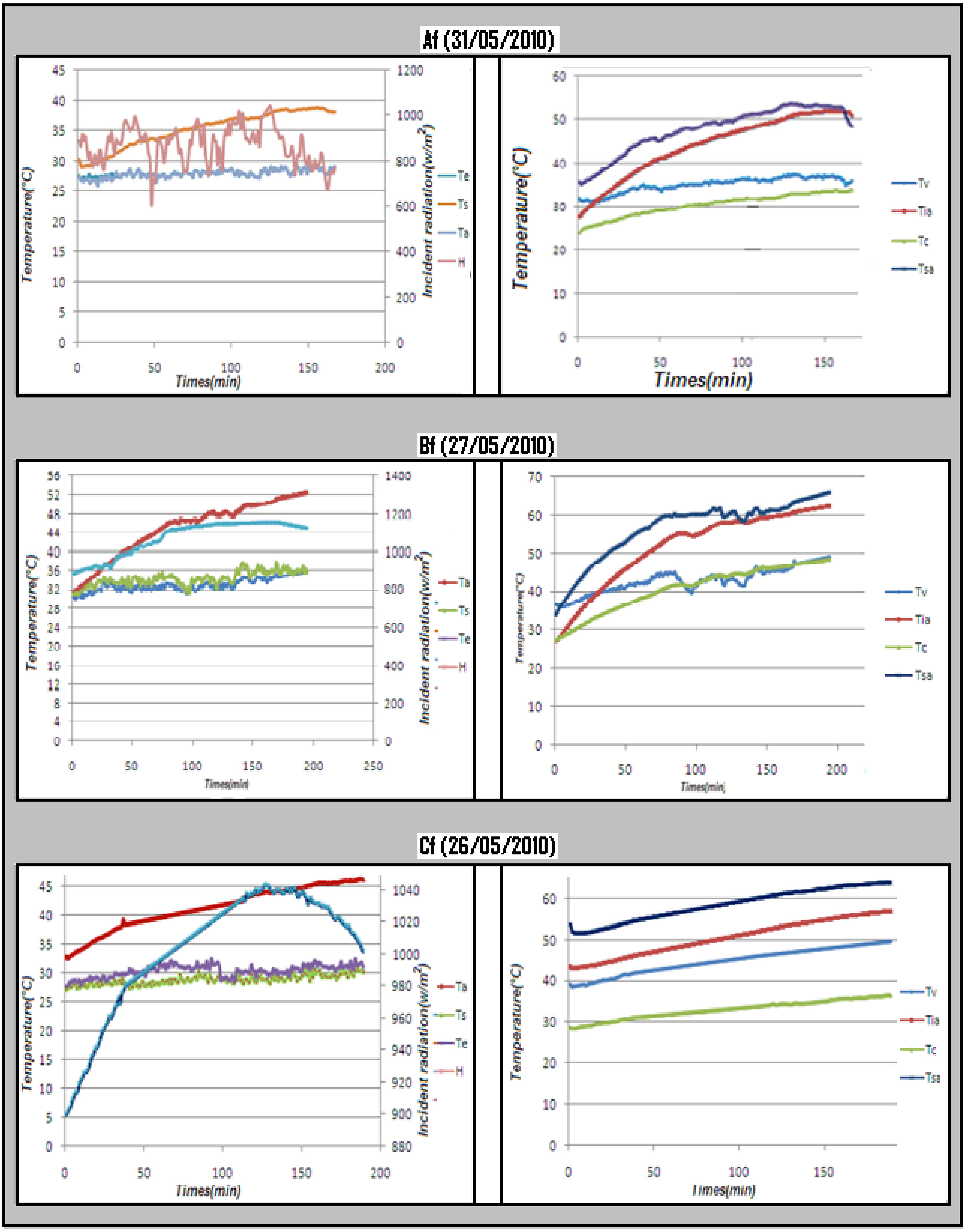

Fig. 4 Temperature and radiation temporal evolution for the three models in forced convection.

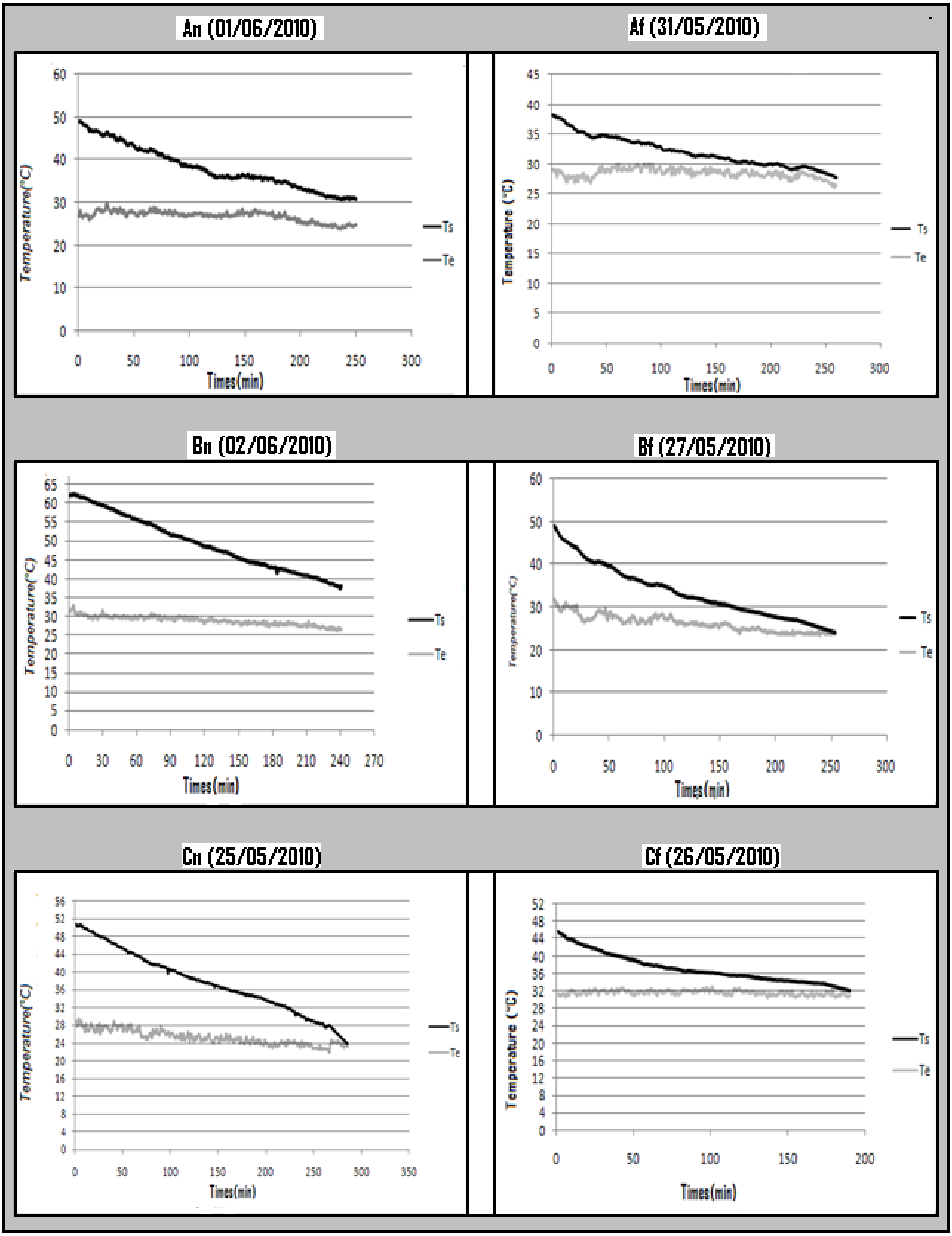

Fig. 5 Inlet and outlet temperature temporal evolution for three models for the two air flows (destocking phase).

Table 1 Useful and stored energy and thermal efficiency for different models and for both air circulation modes and incident radiation.

	Qu (kJ)	*Qst* (kJ)	*H* (KJ)	η (%)
An	2,998.08	2,857	19,083	30
Af	6,037.5	734.7	15,437	42
Bn	3,495.3	3,410.89	22,161.3	31
Bf	7,625.2	6,403.23	23,148	60
Cn	3,666.5	2,871.2	24,294	26
Cf	7,755.4	3,507	20,140	55

5. Conclusions

The results show that model B with forced convection has the best thermal performance with:

- thermal efficiency of around 60%;
- outlet air temperature of about 60 °C;
- low energy loss coefficient (the glass temperature is not high);
- an average temperature high sufficiently at the outlet with speed of about 2 m/s;
- useful and stored energy favorable for home heating and for food drying.

Finally, a further study will be conducted on the B model in forced circulation to determine the long-term performance of this configuration and the possibility of using this type of collect in drying and home heating.

Nomenclature

Ac: collector area (m^2)
Tfe: air inlet temperature (°C)
Tfs: air outlet temperature (°C)
$\dot{m}$: air mass flow rate (kg/s)
Cp: specific heat of air (kj/kg·K)
Δt : time interval between two successive measurements (s)
ρ: air density (kg)
S_s: output section of the collector (m²)
V_s: velocity of air at the collector outlet (m/s)
q_u: useful energy (kj)
q_{st}: energy stored in the collector (kj)
H: incident radiation on the collector (kj)
Q_r: energy received by the collector (W).

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